

EXHIBIT 12

1 IN THE UNITED STATES DISTRICT COURT
2 FOR THE EASTERN DISTRICT OF NORTH CAROLINA
3 SOUTHERN DIVISION
4 No. 7:23-CV-00897

6 IN RE:
7 CAMP LEJEUNE WATER LITIGATION

9 This Document Relates to:

10 | ALL CASES

III

12 EXPERT VIDEO-RECORDED DEPOSITION
13 LEONARD KONIKOW, PHD

15 | Tuesday, February 25, 2025

16 | 9 : 38 AM EST

23 Reported by: Denise Dobner Vickery, CRR, RMR
24 Job No. MDI:G7172979

Tuesday, February 25, 2025

9:38 AM EST

Video-Recorded Expert Deposition of
LEONARD KONIKOW, PHD, held in the conference room
of:

WASHINGTON DULLES MARRIOTT SUITES
13101 Worldgate Drive
Herndon, VA 20170

Pursuant to notice, before Denise
Dobner Vickery, Certified Realtime Reporter,
Registered Merit Reporter, and Notary Public in
and for the Commonwealth of Virginia.

1 APPEARANCES:

2

3 Representing the Plaintiffs Leadership Group:

4 MOTLEY RICE LLC

5 BY: KEVIN R. DEAN, ESQ.

6 28 Bridgeside Boulevard

7 Mt. Pleasant, SC 29464

8 843.216.9239

9 kdean@motleyrice.com

10

11

12

13 Representing the Plaintiffs Leadership Group:

14 WEITZ & LUXENBERG

15 BY: LAURA J. BAUGHMAN, ESQ.

16 700 Broadway

17 New York, NY 10003

18 212.558.5915

19 lbaughman@weitzlux.com

20

21

22

23

24

1 APPEARANCES:

2

3 Representing the United States of America:

4 U.S. DEPARTMENT OF JUSTICE

5 CIVIL DIVISION

6 BY: HAROON ANWAR, ESQ.

7 BY: KAILEY SILVERSTEIN, ESQ.

8 BY: GIOVANNI ANTONUCCI, ESQ.

9 P.O. Box 340, Benjamin Franklin Station
10 Washington, DC 20044

11 202.616.4473

12 haroon.anwar@usdoj.gov

13 kailey.silverstein@usdoj.gov

14 giovanniantonucci@usdoj.gov

15

16 ALSO PRESENT:

17 Gene Aronov, Videographer

18 PRESENT BY ZOOM:

19 Deanna Havai

20 Dennis Reich

21 Tim Thompson

22 Jeffrey Davis

23 Morris Maslia

24 Devin Botlon

Bill Williams

Alex Spiliotopoulos

1		INDEX	
2	EXAMINATION OF LEONARD KONIKOW, PhD	PAGE	
3	BY MR. ANWAR	10	
4	AFTERNOON SESSION	162	
5	BY MS. BAUGHMAN	353	
6	KONIKOW DEPOSITION EXHIBITS		
7	(Attached to transcript.)		
8	NUMBER	PAGE	
9	EXHIBIT 1	Amended Notice of Deposition	18
10	EXHIBIT 2	Rebuttal to Reports of Dr. Alex	21
11		Spiliotopoulos and Dr. Remy J.C.	
12		Hennet, Leonard F. Konikow,	
13		January 13, 2025	
14	EXHIBIT 3	January 2025 Rebuttal - Expert	25
15		Report of Leonard Konikow, PhD,	
16		NAE, Materials Considered List,	
17		January 21, 2025	
18	EXHIBIT 4	Attachment A, Curriculum Vitae	35
19		of Leonard Konikow, PhD, NAE	
20		Attachment B, Publications During	
21		Past 10 Years, January 13, 2025	
22	EXHIBIT 5	Leonard F. Konikow - Consultant	65
23		Invoice, Expert Peer Review, Camp	
24		Lejeune groundwater contamination	

1 problem, October 21, 2024
2 EXPERT_KONIKOW_000000823 - 824
3 EXHIBIT 6 Leonard F. Konikow - Consultant 65
4 Invoice, Expert Peer Review, Camp
5 Lejeune groundwater contamination
6 problem, January 15, 2025
7 EXPERT_KONIKOW_000000825 - 827
8 EXHIBIT 7 The Handbook of Groundwater 100
9 Engineering, Chapter 20
10 EXHIBIT 8 ATSDR Chapter A: Summary of 132
11 Findings, July 2007
12 CLJA_HEALTHEFFECTS-000221172 - 287
13 EXHIBIT 9 ATSDR Chapter A: Summary of 139
14 Findings, March 2013
15 CLJA_HEALTHEFFECTS-000221326 - 513
16 EXHIBIT 10 Modeling Chloride Movement in 150
17 the Alluvial Aquifer at the Rocky
18 Mountain Arsenal, Colorado, 1977
19 By Leonard F. Konikow
20 EXHIBIT 11 History Matching to Determine the 156
21 Retardation of PCE in Ground Water
22 1992, By L. Rogers
23 EXHIBIT 12 Transcript of Expert Peer Review 166
24 Panel ATSDR's Historical

1	EXHIBIT 16	ATSDR Expert Panel Meeting Analysis for Historical Reconstruction of Groundwater Resources and Distribution of Drinking Water at Hadnot Point, Holcomb Boulevard, and Vicinity, U.S. Marine Corps Base Camp Lejeune, North Carolina, April 30, 2009	278
9	EXHIBIT 17	ATSDR Chapter F: Simulation of the Fate and Transport of Tetrachloroethylene (PCE), 2008	286
12	EXHIBIT 18	Predictive Accuracy of a Ground-Water Model - Lessons from a Postaudit by Leonard F. Konikow, 1986	293
15	EXHIBIT 19	Letter of February 21, 2007 to Dr. Konikow from Morris Maslia	310
17		EXPERT_KONIKOW_000000006 - 21	
18	EXHIBIT 20	ATSDR Responses to the Department of the Navy's Letter, March 2009	331
20		CLJA_WATERMODELING_01-09_-	
21		0000033263 - 329	
22	EXHIBIT 21	Exposure to Contaminants in Water Supplies at Camp Lejeune	345
23		CLJA_HEALTHEFFECTS-000000479 - 517	
24			

1 P R O C E E D I N G S
2 - - -
3 THE VIDEOGRAPHER: Good
4 morning. We are now on the record.
5 My name is Gene Aronov. I'm
6 videographer for Golkow Veritext
7 division. Today's date is February 25th
8 and the time is 9:38 AM.

9 This video deposition is being
10 held at the Washington Dulles Marriott
11 Suites, 13101 Worldgate Drive, Herndon,
12 Virginia in the matter of Camp Lejeune
13 Water Litigation versus United States of
14 America for the Eastern District of North
15 Carolina. The deponent is Leonard
16 Konikow.

17 Would counsel please introduce
18 themselves for the record.

19 MR. DEAN: Good morning.
20 Kevin Dean on behalf of the Plaintiffs
21 Leadership Group and the witness.

22 MS. BAUGHMAN: Laura Baughman
23 on behalf of Plaintiffs Leadership Group
24 and the witness.

1 MR. ANWAR: Haroon Anwar
2 Department of Justice for the United
3 States.

4 MR. ANTONUCCI: Giovanni
5 Antonucci for the United States.

6 MS. SILVERSTEIN: Kailey
7 Silverstein for the United States.

8 THE VIDEOGRAPHER: The remote
9 participants will be noted on the
10 stenographic record.

11 The court reporter is Denise
12 Vickery will now swear in the witness.

13 - - -

14 LEONARD KONIKOW, PHD
15 called for examination, and, after having been
16 duly sworn, was examined and testified as
17 follows:

18 - - -

19 EXAMINATION

20 - - -

21 BY MR. ANWAR:

22 Q. Good morning, Dr. Konikow.

23 A. Good morning.

24 Q. My name is Haroon Anwar. I am a

1 lawyer for the Department of Justice here to take
2 your deposition today in the Camp Lejeune Justice
3 Act Litigation.

4 A. Okay.

5 Q. Do you understand that?

6 A. Yes.

7 Q. Okay. Have you ever sat for a
8 deposition before?

9 A. One time.

10 Q. Okay. Well, you may recall that
11 experience, but I just wanted to go over some
12 ground rules to help the deposition today go as
13 smoothly as possible.

14 A. Good.

15 Q. First, you're -- you're under the
16 oath to tell the truth as if you were in an actual
17 court of law.

18 A. Okay.

19 Q. Do you understand that?

20 A. Yes, I do.

21 Q. And is there any reason, sitting
22 here today, that you would be unable to testify
23 truthfully?

24 A. No.

1 Q. Okay. We have a court reporter
2 sitting right next to you taking down everything,
3 typing down everything for the record.

4 A. (Nods head).

5 Q. To make life easier for her, if we
6 could avoid speaking over each other --

7 A. Okay.

8 Q. -- it will -- it will make for a
9 cleaner record and a happier court reporter. She
10 can't get everything down when we're speaking over
11 each other.

12 A. (Nods head).

13 Q. Fair enough?

14 A. Fair enough.

15 Q. Okay. And sort of corollary to that
16 is, to help with that, if you could pause or after
17 I ask my question, maybe pause for a second and
18 then respond.

19 Fair enough?

20 A. Okay.

21 Q. Okay. If I ask a bad question or a
22 question that you need clarification on -- and
23 it's very possible I would do that today -- could
24 you let me know, please?

1 A. I will.

2 Q. Okay. If you don't let me know, I
3 will assume that you understood the question.
4 Fair?

5 A. Yes.

6 Q. Okay. Now, we'll be going for a few
7 hours today. If at any point you need a break,
8 just let me know. This isn't intended to be
9 punishment. The only -- the only stipulation I
10 would put on that is if there's a pending
11 question, I'd ask that you answer that question,
12 and then we can take a break.

13 Fair enough?

14 A. Yes.

15 Q. Okay. And I'll try to take a break
16 every hour or so anyway.

17 A. Good. Okay.

18 Q. Now, I want to start by asking you
19 what you did to prepare for today's deposition.

20 A. Well, a number of things. Over the
21 past several weeks, I reviewed all of the reports
22 from ATSDR for the Tarawa Terrace model and Hadnot
23 Point/Holcomb Boulevard.

24 Last week I flew down to South

1 Carolina to meet with these lawyers, a few other
2 lawyers, and Morris Maslia were there for
3 basically two days of meetings. And then
4 yesterday I met with Kevin and Laura just to
5 discuss general questions, such as the things you
6 just pointed out to me and had to respond.

7 Q. Sure.

8 A. Yeah.

9 Q. For the meeting last week, the
10 two-day meeting in South Carolina with the lawyers
11 and Mr. Maslia, was there anyone else present
12 besides lawyers and Mr. Maslia?

13 A. Besides the lawyer -- there were
14 several lawyers and myself and that's -- that's
15 all I recall being there.

16 Q. Okay. No -- no non-lawyers other
17 than Mr. Maslia?

18 A. No what?

19 Q. No non-lawyers other than
20 Mr. Maslia?

21 A. I don't believe so.

22 Q. Did you review any documents during
23 that meeting?

24 A. What do you mean by "reveal"?

1 Q. Did you review documents?

2 A. Oh, review?

3 Q. Correct.

4 A. During the meeting?

5 Q. During the meeting last -- last
6 week, the two-day meeting with the lawyers and
7 Mr. Maslia.

8 A. We may have looked things up for to
9 check some facts, but I don't think there was
10 anything that was a review of a document
11 necessarily. I mean, we looked at some documents
12 to answer some questions, but, you know, in terms
13 of reviewing, if you mean like a technical review,
14 that was not done.

15 Q. Okay.

16 A. But for specific points, there may
17 have been discussions.

18 Q. Understood.

19 Did you -- I guess understanding I'm
20 not asking about technical review sort of from a
21 scientific perspective. Understanding that you
22 are a scientist.

23 Did the documents that you reviewed
24 with the lawyers and Mr. Maslia, did they help

1 refresh kind of your recollection about points
2 that you were discussing?

3 A. It did. Occasionally, you know,
4 something would come up, and we would look at one
5 of the reports that ASDR -- ATSDR published.

6 Q. Okay. Do you recall what documents
7 you reviewed during the two-day meeting last week?

8 A. I believe we looked at the chapter
9 of the Tarawa Terrace that described the summary
10 and findings and probably the groundwater flow
11 model and maybe even the transport model.

12 Q. That was for Tarawa Terrace?

13 A. Tarawa Terrace and similar, you
14 know, I don't remember exactly which ones we
15 looked at, but I suspect we did the same types of
16 documents for Hadnot Point when we talked about
17 that.

18 Q. Understood.

19 Do you recall during last week's
20 two-day meeting reviewing any other documents?

21 A. I do not.

22 Q. How about during yesterday's
23 meeting? Was that -- did that meeting take place
24 with Kevin and Laura?

1 A. It was in this room yesterday.

2 Q. Okay. And with the attorneys --
3 with your attorneys here present today; correct?

4 A. The two attorneys that are here
5 today, yes.

6 Q. Understood.

7 Did you review any documents during
8 yesterday's meeting?

9 A. I don't -- I don't recall that we
10 did. I mean, maybe I don't remember, but I don't
11 remember us reviewing any documents yesterday.

12 Q. Understood.

13 About how long -- how long did the
14 meeting yesterday last?

15 A. It was probably about six hours, not
16 counting lunchtime.

17 Q. All right. Did you do anything else
18 besides the two separate meetings that we've
19 discussed to prepare for your deposition today?

20 A. To prepare for the deposition? No,
21 not that I can think of.

22 Q. Okay. But -- and I should say,
23 besides the two meetings last week and this week
24 with your -- the lawyers and Mr. Maslia and then

1 you had testified, I believe, that you had went
2 through and reviewed the ATSDR modeling reports;
3 correct?

4 A. Yes.

5 Q. Okay. Besides that, did you do
6 anything else to prepare for your deposition
7 today?

8 A. No.

9 Q. Okay.

10 (Document marked for
11 identification as Konikow Exhibit 1.)

12 BY MR. ANWAR:

13 Q. I am handing you what is being
14 marked as Konikow Exhibit 1.

15 Have you seen this document before?

16 A. (Reviews document.)

17 Yes, this looks familiar.

18 Q. Okay. I'll represent to you it's
19 the notice for deposition and the subpoena
20 scheduling your deposition --

21 A. Yeah.

22 Q. -- today.

23 A. Okay.

24 Q. I wanted to direct your attention to

1 Attachment A. There are three document requests
2 there.

3 The first one is for e-mails,
4 letters, correspondence, text messages,
5 conversations, chats, voicemails, and
6 communications pertaining to Camp Lejeune prior to
7 your retention as an expert in this litigation.

8 Do you see that there?

9 A. Yes.

10 Q. And we received a document
11 production from your counsel last night.

12 A. Yeah.

13 Q. Did that document production contain
14 all of the responsive documents or communications
15 you have in response to request number 1?

16 A. Well --

17 MR. DEAN: Object to form,
18 except, you know, we've served an
19 objection.

20 MR. ANWAR: Understood.

21 MR. DEAN: So subject to that.

22 THE WITNESS: I had responded
23 I believe, several weeks ago with e-mails
24 and then yesterday with other documents

1 that I realized were covered up. But I
2 wasn't intentionally not, you know, I
3 wasn't intentionally not sending those
4 forward.

5 I just -- I was focused on the
6 e-mails, letters, correspondence part of
7 this, and I had some files from my
8 service on the expert panels in 2005 and
9 2009. And until Sunday, this past
10 Sunday, it just didn't pop into my head
11 that those were covered by this. It was
12 just an oversight on my part.

13 BY MR. ANWAR:

14 Q. Understandable and, you know, I'm
15 not suggesting you did anything --

16 A. Yeah.

17 Q. -- anything wrong.

18 I'm just trying to confirm --

19 A. Yeah.

20 Q. -- whether -- what was produced in
21 response to this subpoena.

22 And so request number 2 is
23 essentially the same thing. E-mails, letters,
24 correspondence, communications with any of --

1 anyone that has filed a claim in this litigation.

5 In response to these three requests,
6 did you give your lawyers everything that you
7 have?

8 A. At this time, I would say I gave
9 everything that I have, yes.

10 Q. Okay. Is there anything that you
11 can think of related to Camp Lejeune prior to your
12 retention as an expert in -- in this current
13 litigation, communications, documents that you
14 have in your possession currently?

15 A. That I have not turned over?

16 0. Correct.

17 A. No. As far as I know, I've turned
18 over everything.

MR. ANWAR: Okay. Thank you.

20 You can set that aside.

21 (Document marked for
22 identification as Konikow Exhibit 2.)

23 BY MR. ANWAR:

24 | O. I'm going to hand you now what is

1 being marked as Exhibit 2. There you go.

2 Dr. Konikow, is this a true and
3 correct copy of the rebuttal report -- expert
4 report that you submitted in this case?

5 A. It appears to be.

6 Q. Okay. Is there anything in your
7 rebuttal report -- well, let me back up for a
8 second.

9 This rebuttal report on page 33 is
10 dated January 13; correct?

11 A. Yes.

12 Q. That's when you signed the report;
13 correct?

14 A. And sent it probably to Kevin, yes.

15 Q. Sure.

16 And is that your electronic
17 signature there on page 33?

18 A. It is.

19 Q. Okay. Since submitting the report
20 and giving it to the lawyers on January 13, 2025,
21 is there anything in your rebuttal report that you
22 now believe is incorrect?

23 A. Yes.

24 Q. What -- what is that?

1 A. On page 10 -- let me look at my
2 copy. Page 11 line 10 it says "equivalent to a
3 fraction or 0.001," the word or should be "of"
4 o-f. So just a typographical error.

5 Q. Understood.

6 And this is the sentence starting
7 with "OCC is equivalent to TOC?

8 A. Yes.

9 Q. "And 0.1% is equivalent to a
10 fraction of .001"?

11 A. Yes.

12 Q. Is there anything else, as you sit
13 here today, that you believe is incorrect in your
14 report?

15 A. No.

16 Q. Is there anything in your rebuttal
17 report that needs to be updated, as you sit here
18 today?

19 A. Not that I'm aware of, no.

20 Q. Is there any portion of your
21 rebuttal report that you believe is incomplete?

22 A. Not -- no, not that I can think of.

23 Q. And does your rebuttal report
24 contain all of the opinions that you intend to

1 offer in this case?

2 MR. DEAN: Object to the form.

3 Subject to anything that you might ask
4 him in the deposition not covered by the
5 notice -- I mean, the report.

6 THE WITNESS: I may have
7 other opinions. I'm not, you know, I
8 mean, from my review of those two expert
9 reports, these are the comments that I
10 felt were significant criticisms that I
11 thought were worth making.

12 If something else comes up, I
13 probably have another opinion. So I
14 don't think I could say that these are
15 the only opinions I would give. You ask
16 me a question, I'll give you my opinion.

17 BY MR. ANWAR:

18 Q. Sure.

19 So aside for any conversation we
20 have in the deposition today, does this report
21 contain all of the opinions that you intend to
22 offer in the litigation?

23 A. Well, you, again, if I, you know, if
24 I'm asked questions about something other than

1 this, I would offer an opinion on it.

2 So I'm really not sure about the
3 question what -- what it is encompassing but...

4 Q. Sure. I understand that.

5 I guess with the caveat that we may
6 discuss things both contained in your report and
7 not directly referenced in your report in today's
8 deposition.

9 Putting that aside, is there
10 anything -- are there any other opinions that
11 you're currently aware of that you intend to offer
12 in this case that aren't reflected in your report?

13 A. Not that I can think of.

14 Q. Okay.

15 (Document marked for
16 identification as Konikow Exhibit 3.)

17 BY MR. ANWAR:

18 Q. I'm going to hand you what I'm
19 marking as Konikow Exhibit 3.

20 A. (Reviews document.)

21 Q. Dr. Konikow, is this a complete list
22 of the materials you considered in forming the
23 opinions in your rebuttal report?

24 A. I believe so.

1 Q. Okay.

2 A. I'll look. There's a number of
3 documents listed at the end, and I'm not sure
4 exactly what those refer to.

5 Q. Okay. This document, Exhibit 3,
6 that I handed you, it's titled "January 2025
7 Rebuttal Expert Report of Leonard Konikow, PhD,
8 National Academy of Engineering" and then
9 underneath it says "Materials Considered List" and
10 it's dated January 21, 2025; is that right?

11 A. Yes.

12 Q. Okay. And as you sit here
13 currently, you're not aware of anything else that
14 should have been included on this Materials
15 Considered List that's not included?

16 A. Not that I'm aware of.

17 Q. Okay. Did you review the rebuttal
18 reports of or the rebuttal report of Morris
19 Maslia?

20 A. I believe I did.

21 Q. Okay.

22 A. I don't recall it specifically,
23 though.

24 Q. But you may have?

1 A. Yes.

2 Q. Did you review a rebuttal report
3 from David Sabatini?

4 A. I believe I saw it. I saw something
5 from Sabatini.

6 Q. Okay. Did you review the rebuttal
7 report from Norman Jones and Jeffrey Davis?

8 A. Yes.

9 Q. And did you review the rebuttal
10 report from Kyle Longley?

11 A. I -- I don't -- I -- yeah, I'm not
12 sure which report that was. Is that the one
13 related to the history or something?

14 Q. Yeah. Correct.

15 A. I think it was sent to me and I just
16 glanced at the first page or so, and I did not
17 review that whole report.

18 Q. Understood.

19 Do you have any opinions about
20 the -- any of those rebuttal reports that aren't
21 reflected in your -- in your own report?

22 A. Well, my report really focused on
23 Alex and Remy's report, and I don't think there's
24 any comments in here on the other rebuttal

1 reports.

2 Q. Okay. And as you sit here today,
3 you don't intend to offer comments on the other
4 rebuttal reports outside of any discussion we may
5 have today in the deposition?

6 A. Correct.

7 Q. Okay. Did you listen to or review
8 the transcripts for the deposition of Mustafa
9 Aral?

10 A. I did. Yes, I looked at it. I read
11 it.

12 Q. Okay. Did you either listen to or
13 review the transcripts for the depositions of
14 Norman Jones and Jeffrey Davis?

15 A. I believe I did.

16 Q. Do you have any opinions about
17 anything that was said in those depositions that
18 aren't reflected in your -- your own expert
19 report, your rebuttal report?

20 MR. DEAN: Object to the form.

21 Subject to whatever you may ask in this
22 deposition or I do as a follow-up.

23 BY MR. ANWAR:

24 Q. You can answer.

1 A. Well, there's nothing in my expert
2 report about the testimony or deposition of Jones
3 and Davis. I read it. I may have some opinions
4 on it, but it was nothing that belonged in my
5 rebuttal report.

6 Q. Okay. Outside of any discussion we
7 have today in the deposition, do you intend to
8 offer any opinions related to anything that was
9 said in -- well, strike that.

10 Outside of any discussion we have
11 today during our -- the deposition, as you sit
12 here, do you intend to offer any opinions based on
13 the depositions of Mustafa Aral, Norman Jones, and
14 Jeffrey Davis?

15 A. That's not my intent, but if I'm
16 asked, I would try to answer the question to the
17 best of my ability.

18 Q. Understood. Thank you.

19 Do you know Norman Jones?

20 A. I've met him once or twice. I do
21 not know him personally very well, just, you know,
22 other than an introduction at a professional
23 meeting or something like that.

24 Q. Where did you meet him?

1 A. I've attended so many professional
2 meetings in the last 40 years, I really -- I don't
3 remember. It may have been a National Ground
4 Water Association meeting. It may have been a
5 Geological Society of America meeting. I go to,
6 you know, many of these and occasionally our paths
7 him across. It was probably one or two sessions
8 where we were both speakers in a symposium, and
9 I'm sure I shook hands with him, said hello, but
10 nothing more than that.

11 Q. Understood.

12 Aside from crossing paths in
13 professional settings once or twice, it sounds
14 like you haven't -- you don't know Norman Jones
15 otherwise; correct?

16 A. When I was -- well, basically the
17 answer is no, I don't know him, but I believe I
18 had another interaction with him in the last five
19 years related to a man- -- I was editor-in-chief
20 of Groundwater Journal for four years. And during
21 that time, I believe he had submitted one
22 manuscript not related to Camp Lejeune, and so we
23 had some correspondence related to that, but had
24 nothing to do with Camp Lejeune.

1 Q. Do you have any recollection what
2 that manuscript was about?

3 A. I believe it was about an area
4 called Spring Valley in Nevada or an adjacent area
5 in Utah. I know it focused on the City of Las
6 Vegas, trying to develop well fields in an area
7 maybe a couple hundred miles north of Las Vegas,
8 but in a valley in Nevada that extended into Utah.
9 And they wanted to develop water supplies on the
10 Nevada side, pump a lot of wells, and it would
11 have had impacts on the Utah side. So he was --
12 the manuscript focused on that situation.

13 Q. Well, did that manuscript involve
14 groundwater or transport modeling? Do you recall?

15 A. My recollection it probably, but I
16 can't -- I don't have total recollection. It
17 probably involved groundwater flow modeling.

18 Q. Okay.

19 A. Probably did not involve transport
20 modeling.

21 Q. Understood.

22 In that instance, it sounds like it
23 may have involved groundwater modeling for the
24 purposes of developing supply wells outside of Las

1 Vegas; is that right?

2 A. It was related to that, but I think
3 his focus was on assessing the impacts of that
4 pumpage on water supplies on the aquifers in Utah.

5 Q. Okay. Aside from that manuscript,
6 have you worked with Norman Jones on any other
7 projects?

8 A. No.

9 Q. Do you know Mustafa Aral?

10 A. I've met him.

11 Q. Okay. In what context have you met
12 Dr. Aral?

13 A. Serving on expert peer review panels
14 for ATSDR in 2005 and 2009. I believe he was at
15 both of those meetings, to the best of my
16 recollection, and I met him there and we may have
17 talked. You know, I don't remember. I believe he
18 gave some presentations to the expert panel
19 committees, but I don't remember the details.

20 I don't recall ever meeting him
21 outside of those two meetings.

22 Q. Have you ever worked with Dr. Aral
23 before outside of those two meetings, the ATSDR
24 meetings?

1 A. No, not to recollection.

2 Q. Do you know Jeffrey Davis?

3 A. I believe I met him somewhere along
4 the line, but I can't recall the occasion. I saw
5 he said he was involved with the board of
6 directors of National Ground Water Association,
7 and while I was an editor for their journal, we
8 probably attended meetings together at their
9 annual meetings. And we probably talked there,
10 but I have no direct recollection of that.

11 Q. Okay. So outside of those
12 professional meetings, you don't know Jeffrey
13 Davis; is that right?

14 A. That's correct.

15 Q. Have you ever -- and you haven't
16 worked with Mr. Davis before?

17 A. Not that I could recall.

18 Q. Do you -- do you know David
19 Sabatini?

20 A. No.

21 Q. Never met?

22 A. Well, again, I may have met. If he
23 was at the 2005 or 2009 meetings, I probably met
24 him, but I do not recall meeting him.

1 Q. Understood.

2 Earlier you mentioned reviewing all
3 of the ATSDR reports.

4 It sounds like the modeling reports
5 for Tarawa Terrace as well as the model --
6 modeling reports related to Hadnot Point and
7 Holcomb Boulevard; is that right?

8 A. That's correct.

9 Q. Did you do anything further than
10 review the reports?

11 A. I'm not sure what that would --
12 could include, but no, I mean, I read the reports.
13 I didn't do anything else with them.

14 Q. Did you attempt to reconstruct
15 ATSDR's models for Tarawa Terrace or Hadnot Point
16 and Holcomb Boulevard?

17 A. I did not.

18 Q. Did you attempt to reevaluate the
19 input parameters or assumptions upon which the
20 Tarawa Terrace model or the Hadnot Point/Holcomb
21 Boulevard model were based?

22 A. Well, I mean, part of my review was
23 looking at their discussions of the parameter
24 values, and I certainly, you know, considered them

1 and looked at, you know, what, you know, that they
2 looked reasonable, you know.

3 Q. Outside of what's contained in your
4 report and what we -- we discuss today, do you
5 have any -- any opinions about ATSDR's parameter
6 of values or input values?

7 A. Can you repeat that, please?

8 Q. I guess -- well, let's -- we'll come
9 back to that. Let's that was maybe a bad
10 question.

11 I'm going to hand the court reporter
12 to hand you what is being marked as Konikow
13 Exhibit 4.

14 (Document marked for
15 identification as Konikow Exhibit 4.)

16 THE WITNESS: (Reviews
17 document.)

18 BY MR. ANWAR:

19 Q. The first page of Exhibit 4 states
20 "Attachment A" which was attached to your expert
21 report, and Attachment A is a copy of your
22 curriculum vitae; correct?

23 A. Yes.

24 Q. Okay. Is this a true and accurate

1 copy of your curriculum vitae?

2 A. Yes.

3 Q. Is it current?

4 A. Pretty current. I think I updated
5 it a couple months ago.

6 Q. To the best of your knowledge, as
7 you sit here today, is there anything that you
8 need to update on this curriculum vitae?

9 A. No. Again, this -- this
10 includes -- it's not a complete detailed list of
11 everything I've ever done professionally --

12 Q. Okay.

13 A. -- but it's, you know, what I could
14 get in two pages.

15 Q. Okay. How did you decide what to
16 include on your curriculum vitae versus what not
17 to include in terms of, you know, everything that
18 you've done professionally?

19 A. Well, I included the points that I
20 think people would expect to see in a curriculum
21 vitae, my education, so on, and highlights of
22 publications and professional side activities. A
23 few awards that I received that I thought were of
24 particularly high recognition, but I did not

1 include every award I've ever received or every
2 publication I've ever had published.

3 Q. Understood.

4 As part of Exhibit 4, there's also
5 an Attachment B, which is Attachment B to your --
6 your rebuttal report, and it's titled
7 "Publications During Past 10 Years."

8 Is that right?

9 A. Yes.

10 Q. Is this a complete list of your
11 publications during the past 10 years?

12 A. To the best of my knowledge, it is.

13 Q. I wanted to ask you a few questions
14 about items on your CV.

15 I wanted to start by asking you
16 whether you would describe yourself as a
17 hydrogeologist; is that right?

18 A. That's how I usually describe
19 myself, yeah.

20 Q. Is there any other title that you
21 describe yourself with?

22 A. Occasionally, you know, my official
23 job position with -- during my career with the
24 U.S. Geological Survey, most of the time I was

1 called, in fact probably all the time, I was
2 called a research hydrologist.

3 Q. Okay. Do you consider yourself an
4 expert in groundwater transport and water
5 distribution modeling?

6 A. I am not an expert in water
7 distribution modeling, but I do consider myself an
8 expert in groundwater flow and transport processes
9 in modeling.

10 Q. Is there any other subject area that
11 you consider yourself an expert in?

12 A. I think hydrogeology, groundwater
13 flow, and transport processes probably encompasses
14 all of it.

15 Q. Okay. Now, you spent the bulk of
16 your career at the U.S. Geological Survey; right?

17 A. Yes, sir.

18 Q. And then it looks like from your CV
19 your most recent role was editor-in-chief of
20 Groundwater Journal from 2020 to 2023; is that
21 right?

22 A. Yeah, four years.

23 Q. Four years from 2020 to 2023?

24 A. Yeah, inclusive. All those years,

1 you know, from January 1st of 2020 to December
2 31st of 2023.

3 Q. Understood.

4 A. Are you currently retired?

5 (Laugh). A. Yes. Well, except for this.

6 Q. Except for the serving as a Camp
7 Lejeune expert; correct?
8

9 A. Yes.

10 Q. Okay. Under -- I wanted to talk to
11 you a little bit about some of your selected
12 professional activity on your CV.

13 It looks like that throughout your
14 career you've served on committees or panels for
15 the National Research Council; is that right?

16 A. That's correct.

17 Q. Okay. From -- and I'm looking at
18 your CV.

19 From 1981 to 1982, you served on an
20 NRC panel on groundwater contamination; is that
21 right?

22 A. That is correct.

23 Q. What did you do in this role?

24 A. Well, to the best of my

1 recollection, again, that one is, you know, more
2 than 40 years ago, but as a panel member, we
3 discussed the -- the problem of groundwater
4 contamination, which was just in the late '70s
5 becoming much more widely recognized as an
6 important problem.

7 And the National Research Council
8 had asked me to serve on this panel, and I thought
9 it was a worthwhile activity. We would typically
10 have discussions among the whole committee, as
11 well as listen to presentations from experts that
12 they brought in. I had no role in selecting who
13 they brought in but, you know, and then we would
14 have discussions.

15 And then somewhere after, you know,
16 the first or second meeting, we started working on
17 writing a report and, to the best of my
18 recollection, a book came out from that activity.

19 Q. What book came out of that activity?

20 A. I believe it was just a National
21 Research Council report published by National
22 Academy Press. Something in the title about
23 groundwater contamination. There may have been
24 some other words there, but I don't recall. I

1 haven't looked at that report in a while.

2 Q. Okay. Did you take part in writing
3 any part -- any portion of that book?

4 A. Most likely, yeah.

5 Q. So either on the book itself or in
6 the chapters, you likely would be listed as an
7 author?

8 A. I don't know that they listed
9 authors. I think they listed it in terms of who
10 was members of the committee that wrote the
11 report.

12 Q. Understood.

13 Do you know how you were selected to
14 serve on that NRC committee on groundwater
15 contamination?

16 A. No, I do not.

17 Q. You mentioned, I guess, other
18 experts served on that committee; correct?

19 A. Yeah. Yes.

20 Q. Would it be fair to say you were
21 selected to serve on that committee because of
22 your expertise as a hydrogeologist?

23 A. I presume so.

24 Q. Do you know how other experts were

1 selected to serve on that committee?

2 A. I do not.

3 Q. Do you remember any of the experts
4 that you -- you served on that committee with?

5 A. On that committee, I do not
6 remember. I did not look at that report probably
7 in the last year or two years or five years. I
8 just -- I don't remember who else was on that
9 committee. If I looked at the report, it would
10 refresh my memory.

11 Q. Understood.

12 Now, looking further on your CV, it
13 looks like from 1987 to 1989 you served on an NRC
14 Committee on Ground-Water Modeling Assessment; is
15 that right?

16 A. From '87 to '89, yeah. Committee on
17 Ground-Water Modeling Assessment, yes.

18 Q. What was the committee or what is
19 the Committee on Ground-Water Modeling Assessment?

20 A. Again, this is done at a time when
21 groundwater modeling was becoming much more
22 widespread and -- and, you know, particularly in
23 the public there wasn't a widespread appreciation
24 among the public or probably politicians and

1 others, senior level government officials, about
2 what groundwater models could do, how reliable
3 they were and so on. And so this -- this
4 committee was, I believe, was charged to review
5 the state of the art of groundwater modeling.

6 It's not shown here, but like a
7 subtitle of this committee, or at least of the
8 book that was produced, was something to the
9 effect of groundwater models in a regulatory and
10 environmental framework or assessment, something
11 like that. There was, you know, some additional
12 subtitle that is not listed here. I was trying to
13 keep everything on one line here.

14 Q. Understood.

15 What do you -- what did you do in
16 this role on the -- the NRC Panel on Ground-Water
17 Modeling Assessment?

18 A. We discussed the philosophy of
19 modeling. We discussed the mathematical basis
20 underlying the model. We discussed parameter
21 estimation for the models, how reliable the
22 results are, you know, things on that order, yeah.

23 Q. Do you know how it came to be that
24 you were selected to be on that committee?

1 A. No, I do not.

2 Q. Did you apply to be on that
3 committee?

4 A. No. I usually don't volunteer for
5 things. (Laugh).

6 Q. Understood.

7 It sounds like you were selected to
8 serve on that committee then?

9 A. Somebody asked me, I don't remember
10 who, and I thought it was a worthwhile activity at
11 the time and so I said sure.

12 Q. Okay. Do you recall any of the
13 members of -- the other members that served on the
14 Groundwater Modeling Assessment Committee?

15 A. I do.

16 Q. Who? Who were they?

17 A. Frank Schwartz was the chairman of
18 the committee. He is a professor at Ohio State
19 University. You know, I've known him off and on
20 for many years. Jim Mercer was on that committee.
21 Jim was one of the founders of a company called
22 GeoTrans. I was more or less personal friends
23 with Jim Mercer. He -- his company -- he used to
24 work for the USGS. Formed his own company around

1 1980. That company was later bought by Tetra
2 Tech, a larger consulting company.

3 I believe Charlie Andrews from
4 Papadopoulos & Associates was on this committee.
5 I've known Charlie off and on, you know, over the
6 years, at least since this time.

7 Just off the top of my head I can't
8 think. I know there were other people on the
9 committee, but I can't recall who.

10 Q. Sure.

11 Now, you mentioned some of the work
12 you did on that Committee about Ground-Water
13 Modeling Assessment.

14 Do you recall sort of more
15 specifically the nature of that work? Were you --
16 were you evaluating sites? Were you -- or were
17 you discussing sort of modeling as a -- as a
18 science of itself?

19 A. I would say both. I think the
20 report focused mostly on the state of the art of
21 modeling. I do recall there were two or three
22 case histories, site-specific studies that were
23 included in the book of examples to illustrate
24 examples of the application of models to real

1 world complex problems.

2 Q. Do you recall what any of those
3 sites -- three sites were?

4 A. I think one of them was a
5 contaminated site in Ohio. Maybe DynCam, D-y-n.
6 I'm not positive, but that just sort of just
7 popped in my mind.

8 The other one or two examples I
9 just -- I can't recall at the moment but, you
10 know, if I looked at the book, I would see it but,
11 you know.

12 Q. Do you recall how groundwater
13 modeling was involved for that site in Ohio?

14 A. Since it was a contamination
15 problem, I assume there was a groundwater flow
16 model and a related groundwater transport model, a
17 solute transport model.

18 Q. Do you recall whether you were --
19 what the purpose of the model was for that Ohio
20 site?

21 A. I do not.

22 Q. Do you recall whether it was sort of
23 forward-looking or forecasting or whether it was
24 backwards looking and hindcasting?

1 A. I don't recall.

2 Q. Okay. Do you recall what the models
3 for the other two sites were used for?

4 A. I do not recall.

5 Q. Okay. Fair enough.

6 And then on your CV, from 1989 to
7 1997, it looks like you served on an NRC Committee
8 on Waste Isolation Pilot Plant?

9 A. Yes.

10 Q. Could you tell me about that?

11 A. Sure. The Department of Energy had
12 proposed a site near Carlsbad, New Mexico in thick
13 bedded salt deposits for the disposal of
14 radioactive waste, particularly plutonium waste
15 related to weapons production and, you know,
16 typically these were not high-level wastes in the
17 sense of fuel rods from power plants, which would
18 generate a lot of heat, even in a waste form.

19 These wastes although in a sense
20 were high level -- they were very toxic -- they
21 were not generating heat. It was basically
22 plutonium garbage waste products.

23 Q. Understood.

24 A. Yeah.

1 Q. And was there a component on that
2 committee -- committee that involved groundwater
3 flow or transport modeling?

4 A. Yes, that was one of the big
5 concerns, you know, in assessing the safety of the
6 site, the big concern, could anything escape from
7 the site and what's the likely pathway. And it
8 was deemed that, you know, one of the likely
9 pathways, particularly if the site operated to
10 completion in the future and was sealed and
11 closed, the most likely risk would come from water
12 breaching the repository area and then leaking
13 upwards into an overlying permeable aquifer.

14 And then what would happen to that
15 liquid waste in that aquifer. How fast would it
16 move through the aquifer? How would it spread?
17 What kind of risk did it pose to future humans
18 living downgradient of that?

19 So, you know, one of the focus of
20 the committee was to assess the Department of
21 Energy's safety assessment and so we were, you
22 know, we looked very critically at everything they
23 did in terms of trying to demonstrate safety.

24 This was -- and, again, the Waste

1 Isolation Pilot Plant, to my recollection, it was
2 originally proposed as a pilot plant, which
3 implies that this would be somewhat experimental
4 and, you know, not quite a full operational.

5 But at some point they changed the
6 name to the WIPP site, just the initials, and it
7 was pretty clear this was going to be an
8 operation. It wasn't an experiment. It was -- it
9 was planned to be an operational waste --
10 radioactive waste disposal site for what they call
11 transuranic wastes.

12 Q. Understood.

13 And it sounds like you were using
14 groundwater modeling, and you may have mentioned
15 transport modeling, but in this context, you were
16 using it for sort of management or planning
17 purposes, for purposes of?

18 A. Safety I'd say the overriding
19 purpose. There was groundwater flow modeling
20 involved. There was solute transport modeling
21 involved and the overall framework for that and,
22 again, this was just one aspect of many for this
23 committee.

24 Q. Sure.

1 A. The groundwater was just one aspect.
2 There were many things and many other experts
3 involved from other disciplines, but the
4 groundwater flow and transport was really based on
5 a safety assessment. And they were expected to
6 demonstrate safety of the site for 10,000 years
7 into the future.

8 Q. Understood.

9 On this Waste Isolation Pilot Plant
10 Committee, was there -- did you do any modeling
11 work that you would describe as hindcasting or
12 historical reconstruction?

13 A. No.

14 Q. On any of the three NRC committees
15 or panels that you served on, the ones that we've
16 just discussed, have you -- did you do any work
17 model -- modeling work attempting to estimate
18 exposure concentrations for purposes of -- excuse
19 me -- let me -- strike that. Let me -- let me ask
20 that again.

21 On any of these three NRC committees
22 that we've just discussed, did you do any modeling
23 work that was aimed at aiming -- aimed at
24 estimating contaminant concentrations to be used

1 for making exposure determinations on individuals?

2 A. Yes.

3 Q. Which one?

4 A. The WIPP site. The WIPP committee.

5 I didn't personally do those, but one of the
6 things that was done by DOE and evaluated by our
7 committee was potential doses to future humans,
8 farmers, living somewhere downgradient from the
9 site that might be exposed. You know, they might
10 have a well, and what if they or their cows drank
11 water from an aquifer after contaminants passed
12 by.

13 So -- so the answer is yes, that
14 kind of, the dose and the exposure and the
15 consequences had been considered and assessed, but
16 I was not personally involved in any of those
17 calculations, estimations, or assessments.

18 Q. Okay. And that was looking into the
19 future; correct?

20 A. It was looking into, I guess we
21 could say, a hypothetical future.

22 Q. Got you.

23 And I apologize if I asked you this.
24 What was your role specifically on

1 that committee, the WIPP committee?

2 A. Well, I mean, everyone on the
3 committee had, in a sense, an equal role to
4 contribute towards the goals of the committee and
5 assess presentations made to the committee by DOE
6 and their contractors related to the site. So we
7 were, you know, free and open to question anything
8 on any topic if we had questions about it.

9 But, you know, I focused on
10 groundwater flow and transport modeling, but I
11 also looked at their human intrusion scenarios and
12 the risk assessments that they made and, you know,
13 basically anything related to the WIPP site,
14 particularly anything that would have a geological
15 or hydrological connection was a primary interest,
16 but I looked at other things also.

17 Q. Sure.

18 Were you selected to serve on the
19 WIPP committee -- the WIPP site committee?

20 A. I must have been.

21 Q. Okay. In other words, did you
22 volunteer to join that committee, or did someone
23 ask you to join that committee?

24 A. Someone asked.

1 Q. Okay.

2 A. Yeah.

3 Q. Do you recall any of the other
4 members of that committee, the Waste Isolation
5 Pilot Plant, which we've been referring to as
6 WIPP?

7 A. Yeah. When I started on it, there
8 was a professor from Stanford named Konrad
9 Krauskopf, I think it is, who is a geochemist. He
10 was the chairman of the committee when I first
11 came on.

12 John Bredehoeft, a hydrogeologist
13 also worked with the USGS, at least I think at the
14 early part of that time. He retired somewhere
15 around 1990 or so from the Survey. He was on the
16 committee when I first entered, but he had stepped
17 off by the time, you know, before I ended my
18 participation.

19 A geochemist geologist named Rod
20 Ewing was on the committee. An engineer named
21 Chris Whipple was on the committee. You know, I'd
22 have to take another look.

23 Oh, John Garrick, who was an expert
24 in risk assessment was on the committee. There

1 were, you know, five or six other people on the
2 committee that I can't recall their names at the
3 moment.

4 Q. Fair enough.

5 You mentioned undertaking a review
6 of DOE's waste disposal plan on that committee;
7 right?

8 A. Of the Waste Isolation Pilot Plant,
9 yes.

10 Q. Oh, I'm sorry. Of the Waste
11 Isolation Pilot Plant?

12 A. Yes, that was the focus of the
13 committee.

14 Q. How thorough was that review?

15 MR. DEAN: Object to the form.

16 THE WITNESS: Well, you know,
17 I think it was a pretty detailed,
18 in-depth review. You know, I would say
19 always questioning what was presented to
20 the committee, looking to delve a little
21 deeper but, you know, the committee did
22 not, you know, reproduce or test or look
23 at every detail of what was presented to
24 us.

1 It just didn't have the time
2 to do that, but we had, you know, 10 to
3 12 experts in topics ranging from nuclear
4 physics to materials science, risk
5 assessment, probabilistic analyses,
6 hydrogeology, and so on, and so each
7 person tended to ask some pretty
8 thoughtful questions about areas within
9 their expertise.

10 I think there was one
11 expert -- I can't remember his name -- on
12 trains, railroads because it had been
13 proposed that the radioactive waste would
14 be transported by rail to the site.

15 So they got a committee member
16 who was an expert on safety of railroad
17 transportation, and so after a short
18 while they decided they were not going to
19 transport it by rail. So, you know, that
20 was -- but that's an example of the type
21 of expertise that was on the committee.

22 BY MR. ANWAR:

23 Q. Understood. Thank you.
24 Now, these were all NRC committees;

1 correct?

2 A. That was the National Research
3 Council. Sometimes NRC is confused with the
4 Nuclear Regulatory Commission --

5 Q. Okay.

6 A. -- which is also called the NRC.

7 Q. (Laugh).

8 A. But no, this was all National
9 Research Council, which, as best as I understand
10 it, is an arm of the National Academy of Sciences.

11 Q. Okay. And you anticipated my
12 question.

13 I was going to ask you: What is the
14 National Research Council?

15 A. Okay. I'm not sure exactly, but my
16 impression is it is somehow under the realm of the
17 National Academy of Sciences.

18 Q. Do you have any understanding about
19 the national research's -- National Research
20 Council's reputation?

21 A. Well, you know, I think their
22 reports are generally well-respected. It probably
23 varies from report to report, and that probably
24 varies from who the particular experts are on the

1 particular committee were. But if -- if, you
2 know, you want a general report, I think the
3 reports are considered -- for what they do,
4 they're considered to be, you know, reasonable,
5 reliable and, you know, frequently cited.

6 Q. Generally speaking, would you agree
7 that the NRC is considered a reputable and a
8 prestigious organization?

9 MR. DEAN: Object to the form
10 of the question.

11 THE WITNESS: I, you know, I
12 would say it depends on the particular
13 committee but, you know, in general, I
14 think their -- their reports or the books
15 they produce are, you know, considered to
16 be well thought out and reproduced, you
17 know.

18 You know, there's always
19 particular issues that many people might
20 disagree with but, you know, a broad
21 perspective, yes, they are respected.

22 BY MR. ANWAR:

23 Q. Okay. And you mentioned that the
24 National Research Council is part of the

1 national -- or an arm of the National Academy of
2 Sciences; correct?

3 A. Yes. I don't understand perfectly
4 what the relation is, but all I know is they
5 somehow fall under the National Academy of
6 Sciences.

7 Q. What is the National Academy of
8 Science?

9 A. Basically, there are three
10 organizations under that umbrella. One is the
11 National Academy of Sciences, one is the National
12 Academy of Engineering, and one is the National
13 Academy of Medicine and some other word, which I
14 can't remember.

15 So there's like three subspecialty
16 areas and three actually they're considered
17 separate institutes or academies that fall under
18 the national -- it's called the National Academies
19 of Science, Engineering, and Medicine Sciences,
20 something like that.

21 So it, you know, encompasses those
22 three areas and it's a -- my understanding is a
23 nongovernmental organization. Although a lot of
24 their funding comes from government agencies, but

1 I think -- and I may not have this completely
2 accurate, but my impression is they're
3 independent, standalone. They don't fall under
4 any federal agency.

5 Q. The National Academy of Science,
6 isn't it made up of scholars elected by their
7 peers?

8 MR. DEAN: Object to the form
9 of the question.

10 BY MR. ANWAR:

11 Q. You can answer.

12 A. In terms of members, they are
13 elected by existing members is my understanding.

14 Q. Is being elected as a member to the
15 National Academy of Science generally considered
16 to be an honor?

17 MR. DEAN: Object to the form
18 of the question.

19 THE WITNESS: I think so,
20 yes.

21 BY MR. ANWAR:

22 Q. And what is your understanding of
23 the National Academy of Science's reputation?

24 A. My impression is that it has a good

1 reputation. You know, I personally am -- I was
2 elected to membership in the National Academy of
3 Engineering in 2015, and I considered that a high
4 honor.

5 Q. I was going to ask. I was going
6 to -- you've been anticipating my question.

7 A. Sorry.

8 Q. I've heard membership in the
9 National Academy of Science to be considered one
10 of the highest honors a scientist can receive a
11 U.S. scientist.

12 It sounds like you agree with that?

13 A. Basically, yeah. Yes. Yeah.

14 Q. Now, on page 1 of your CV, under
15 Honors and Awards, you have there in bullet
16 points -- in bullet point sort of the last item
17 bolded among all of the items, "Elected to
18 National Academy of Engineering (2015)" --

19 A. Yes.

20 Q. -- correct?

21 A. Correct.

22 Q. Okay. What -- what is the National
23 Academy of Engineering?

24 A. It's one of the three divisions of

1 the National Academy. It's really the National
2 Academies.

3 Q. And why did you list it in bold
4 under a section of your CV entitled "Honors and
5 Awards"?

6 A. I wanted to make sure that it was
7 noticed. (Laugh).

8 Q. Sure.

9 A. I consider it an honor. All the
10 other things listed are honors, but I felt that
11 this was probably, among all of those, the highest
12 honor that I had.

13 Q. Okay. And you list NAE next to the
14 PhD in your name; correct?

15 A. Yeah. Yes. That indicates I'm a
16 member of the National Academy of Engineering.

17 Q. And reflecting the fact that you
18 consider it to be one of the highest honors that
19 you've received; correct?

20 A. Correct.

21 Q. Okay. Now, I wanted to talk to you
22 a little bit more about sort of the scope of your
23 expertise.

24 Earlier we discussed that you would

1 consider yourself a hydrogeologist with expertise
2 in groundwater flow modeling and solute, I think,
3 transport modeling; correct?

4 A. Yes.

5 Q. Okay. And if I understood you
6 correctly, there were -- there were no other areas
7 that you consider yourself an expert in; correct?

8 A. Yeah, I mean, I have some skills in
9 other areas and certainly understandings, but that
10 what you just said is, you know, where I consider
11 my main skills and interests.

12 Q. Okay. And so this is perhaps a bit
13 obvious, so forgive me, but you're not an
14 epidemiologist; correct?

15 A. Correct.

16 Q. You're not a toxicologist?

17 A. Correct.

18 Q. The findings of epidemiology, those
19 aren't within your area of expertise; correct?

20 A. Correct.

21 Q. And that includes the epidemiologic
22 studies or epidemiological studies performed
23 related to Camp Lejeune; correct?

24 A. Correct.

1 Q. You're not an expert on whether a
2 contaminant can cause a disease; correct?

3 A. I'm not an expert on that, no.

4 Q. And you're not an expert on the
5 amount of exposure to a contaminant that can cause
6 a disease; correct?

7 A. That's correct.

8 Q. Okay. Your report sort of in
9 passing or it references MC -- MCL in a few
10 places.

11 What is your understanding of an
12 MCL?

13 A. My understanding is that it stands
14 for maximum contaminant level, and I believe it's
15 a level set by the U.S. Environmental Protection
16 Agency, and it reflects their consideration that
17 any level higher than the MCL creates an undue
18 risk to anyone drinking water with concentrations
19 exceeding that. So it's a level that should not
20 be exceeded in any public water supply.

21 Q. Understood.

22 Have you ever been involved in
23 setting an MCL?

24 A. No.

1 Q. Okay. You're not aware of the
2 methodology that the EPA uses to establish an MCL,
3 are you?

4 A. No.

5 Q. Okay. And you're not aware of how
6 MCLs are set related to health risks; correct?

7 A. No, I'm not.

8 Q. You're not aware; correct?

9 A. Correct, not aware.

10 Q. Okay. Are you aware of whether an
11 exposure above an MCL presents a health risk?

12 A. My general impression is that
13 it's -- the MCL is set to distinguish between what
14 is reasonably safe and what poses a health risk.
15 So anything above it, I would assume, reflects
16 some undue risk.

17 Q. What is that based on? I guess what
18 is your -- that assumption based on?

19 A. It's based on my understanding of
20 why an MCL would be set for particular chemicals
21 by the EPA.

22 Q. Okay. But you haven't ever been
23 involved in setting an MCL yourself and you're not
24 aware of the methodology they use; correct?

1 A. Correct.

2 Q. Okay. Are you aware that for
3 certain chemicals MCLs are set as close to zero as
4 technically feasible?

5 A. No, I'm not aware.

6 Q. Okay. Now, your -- your rebuttal
7 report indicates that you're being paid \$400 an
8 hour for your opinion for your work in this case;
9 correct?

10 A. That's as of January 1st. In 2024 I
11 was charging a lower rate.

12 Q. Okay. What were you charging in
13 2024?

14 A. \$275 an hour.

15 MR. ANWAR: Okay. I'm going
16 to hand you two documents. I'm going to
17 hand to the court reporter to hand you.

18 (Document marked for
19 identification as Konikow Exhibit 5.)

20 (Document marked for
21 identification as Konikow Exhibit 6.)

22 BY MR. ANWAR:

23 Q. I will represent to you that --
24 well, so I've handed you documents that I've

1 marked as Exhibits 5 and 6. These are copies of
2 bills that -- billing records that were produced
3 to us by your counsel last night.

4 Are these true and accurate copies
5 of invoices that you've submitted to the lawyers
6 for time that you've worked on this case?

7 A. Yes.

8 Q. Okay. And so on Exhibit 5, it says
9 on the first page dates of service October 9, 2024
10 to October 21, 2024, that your hourly rate was
11 275, that you worked 19.75 hours, and that the
12 total amount that you charged was \$5,431.25;
13 correct?

14 A. Yes.

15 Q. Okay. And then the next invoice is
16 dated -- Exhibit 6 is dated, dates of service
17 December 12, 2020 -- excuse me -- December 11,
18 2024 to December 31, 2024 with an hour -- hourly
19 rate of 275 per hour, total hours 63.58 for a
20 total amount due of \$17,484.50; correct?

21 A. Correct.

22 Q. Okay. Have you issued any bills for
23 work performed in January yet?

24 A. Not yet. I hope to get to that

1 soon.

2 Q. Okay. Do you have any idea of the
3 total number of hours or the amount of the invoice
4 that you intend to submit for January?

5 A. Let's see. I would guess it's on
6 the order of 100 hours. I have a record of it at
7 home, but I -- I never added it up because I
8 haven't produced the, you know, I haven't gotten a
9 chance to prepare an invoice for January yet. I
10 hope to do that later this week.

11 Q. Okay. When you complete that
12 invoice and issue it to your lawyers, we would
13 request that a copy of that invoice be produced.

14 Is that okay with you?

15 MR. DEAN: No objection.

16 BY MR. ANWAR:

17 Q. And then you mentioned in 2025 your
18 hourly rate has increased to \$400 an hour --

19 A. Yes.

20 Q. -- correct?

21 A. Correct.

22 Q. Have you received any compensation
23 related to Camp Lejeune outside of your paid work
24 as -- currently as a -- as an expert in this

1 litigation?

2 A. No.

3 Q. And I understand that you served on
4 the two ATSDR expert panels on the water modeling;
5 correct?

6 A. Correct.

7 Q. And based on the documents that were
8 produced last night, at that time it looks like
9 you were -- you were with the U.S. Geological
10 Service; correct?

11 A. Survey. Yes.

12 Q. Survey. Excuse me.

13 A. Yeah.

14 Q. And based on the documents that were
15 produced to us last night, it looks like for your
16 participation on the ATSDR expert panels, the U.S.
17 Geological Survey entered into a contract with
18 ATSDR; is that right?

19 A. Yes.

20 Q. Okay. Did you receive any
21 compensation individually for your participation
22 in the expert panels?

23 A. No.

24 Q. Just your salary as a government

1 employee?

2 A. Just I -- yeah, my only compensation
3 was as an employee of the U.S. Geological Survey
4 and, you know, that -- that was it. The contract
5 was between the USGS and ATSDR and I presume to
6 compensate the Survey for my time.

7 Q. Okay. And based on the information
8 we received or the documents that were produced
9 last night, it looks like you were retained as an
10 expert witness in -- for this litigation in
11 October of 2024; is that right?

12 A. That's correct.

13 Q. Okay. And same, based -- based on
14 the e-mails that were produced to us last night,
15 it looks like it was Morris Maslia that put you in
16 touch with Mr. Dean; is that right?

17 A. That is right.

18 Q. Okay. How did you come to the
19 decision to serve as an expert witness for the
20 plaintiffs in this litigation?

21 A. Well, Mr. Dean had contacted me,
22 explained the -- what he was seeking, that he
23 wanted me to serve, you know, to review some
24 documents. I was hesitant because I'm retired,

1 but he explained the problem, and I had certainly
2 some familiarity with Camp Lejeune and the problem
3 because of my service on those two expert panels.

4 So I maintained an interest in it.
5 I thought it was an important issue, an
6 interesting problem from many perspectives, but it
7 was, you know, an interesting use of groundwater
8 modeling and transport modeling. And in spite of
9 being retired, I decided, okay, since this would
10 not be a full-time activity for me, I could take
11 this on.

12 0. Understood.

13 A. You know, plus I would be
14 compensated at a, you know, what I thought was a
15 reasonable rate.

16 Q. Understood.

17 Now, it was Morris Maslia that
18 introduced you to Mr. Dean; correct?

19 A. He had contacted me and asked if it
20 was okay for him to give my contact information to
21 a lawyer.

22 Q. Okay.

23 A. I don't recall that he mentioned
24 Mr. Dean's name at the time, but he may have. I

1 don't know.

2 Q. Okay. How do you know Morris
3 Maslia?

4 A. I've known him for many years. He
5 used to work for the U.S. Geological Survey. I
6 believe he was an attendee at a training class for
7 which I was an instructor.

8 The USGS had a fairly extensive
9 training program. We have a National Training
10 Center in Lakewood, Colorado just outside Denver,
11 and I used to be involved as one of the
12 instructors and for a couple of years as the
13 coordinator for a class on solute transport
14 modeling. And I believe Morris sometime way back
15 was a student in that class, and that's probably
16 the first time I met him.

17 Q. Okay. Around what time frame would
18 that have been when you first met him?

19 A. It -- it was either the late '70s or
20 early '80s is what I gather or what I would guess
21 or estimate, but I don't recall specifically. I
22 would have to look up attendee lists and things
23 like that, which I may or may not even have.
24 But -- so it was probably in the late '70s to

1 early '80s, and then I knew at some point he
2 resigned from the Survey and went to work with
3 ATSDR.

4 Q. Okay. Have you worked with
5 Mr. Maslia on any projects other than the ones at
6 ATSDR related to Camp Lejeune?

7 A. Not that I could recall.

8 Q. Do you think of Mr. Maslia as a
9 professional colleague?

10 A. Yes.

11 Q. Do you consider him a friend?

12 A. In a general sort of way, yes. I
13 mean, we -- we've never socialized, but yeah, I
14 consider him a professional friend.

15 Q. And earlier we discussed the meeting
16 held last week in South Carolina, the two-day
17 meeting, and Mr. Maslia was in attendance;
18 correct?

19 A. Correct.

20 Q. Prior to your involvement in this
21 litigation, prior to your retention in October of
22 2024, when was the last time you had spoken with
23 Mr. Maslia?

24 A. It was several years before that. I

1 can't remember exactly when. We had some e-mail
2 communications. Actually speaking with him, I
3 don't recall the last time we actually spoke in a
4 phone call or anything like that. That's probably
5 quite a while, but we did occasionally have e-mail
6 communications.

7 Q. Understood.

8 Have you ever served as an expert
9 witness in any other litigation?

10 A. No.

11 Q. You mentioned at the beginning of
12 your deposition that you've -- you've been deposed
13 one other time.

14 A. Yeah.

15 Q. Can you describe for me the
16 circumstance of, how did that deposition come
17 about?

18 A. I had done early in my career a lot
19 of work on the Rocky Mountain Arsenal in Colorado
20 where there was pervasive groundwater
21 contamination. Some of the contaminants had
22 migrated beyond the boundaries and affected
23 agricultural lands and farmers north of the
24 arsenal.

1 I had worked on a project to develop
2 a groundwater flow and solute transport model of
3 that area of the whole problem. I probably worked
4 at least two years full time on that project.

5 Can you remind me what the question
6 was again?

7 Q. Sure.

8 A. (Laugh). I strayed off.

9 Q. Why were you deposed in the context
10 of that work?

11 A. Right. So several years after I had
12 completed my work on the Rocky Mountain -- excuse
13 me.

14 Several years later there, the
15 Superfund law was passed and -- and, you know,
16 things happened. During the time that I was
17 working on the, Shell Chemical Company had been
18 a -- had leased facilities on the Rocky Mountain
19 Arsenal and operated those facilities. I believe
20 their primary activity was manufacturing
21 pesticides and herbicides, as I recall.

22 Somewhere years, you know, after I
23 had finished my work, EPA or the government was, I
24 believe, suing Shell Chemical for having generated

1 the waste.

2 The Department of Justice and some
3 lawyers, I mean, they knew I had done work there.
4 So the DOJ sent people to my office to review
5 everything that I had, I mean, everything in my
6 files, related to the Rocky Mountain Arsenal. And
7 sometime after that, they asked me -- well, either
8 asked or told me -- that they wanted to depose me
9 to give a deposition.

10 Q. So you were deposed in that instance
11 as what we -- I guess the lawyers would describe
12 as a fact witness; right? You weren't -- you
13 weren't hired as an expert in?

14 A. I was not hired in any way and to
15 the best of my -- I don't remember the term a
16 "fact witness," but that seems to be a good
17 description of what I was.

18 Q. You were deposed about your
19 knowledge of the events that had taken place;
20 correct?

21 A. Correct.

22 Q. Okay. Now, you submitted your --
23 your expert rebuttal report in this case in
24 response to the reports of DOJ's -- Department of

1 Justice's experts; correct?

2 A. Two experts, correct.

3 Q. And one of those experts is Dr. Alex
4 Spiliotopoulos; correct?

5 A. Yes.

6 Q. And the other expert is Dr. Remy
7 Hennet; correct?

8 A. Correct.

9 Q. Okay. Do you know Dr. Alex
10 Spiliotopoulos?

11 A. Casually. Yes, I do.

12 Q. How do you know him?

13 A. Well, he works for Papadopoulos &
14 Associates. I believe he attended some of the
15 meetings for the expert peer review panels for
16 ATSDR. I've probably seen him occasionally when
17 I've interacted with Papadopoulos & Associates.

18 Q. Sure.

19 Do you know Remy Hennet?

20 A. Yes.

21 Q. How do you know Remy?

22 A. I've met him at a -- probably at
23 least twice at social events, dinner parties that
24 we were both invited to.

1 Q. Okay. Have you ever worked with
2 either Dr. Hennet or Dr. Spiliotopoulos?

3 A. No.

4 Q. Do you know a Gordon Bennett?

5 A. Yes.

6 Q. Okay. And Gordon Bennett, my
7 understanding is he worked at USGS for many years,
8 and is that right?

9 A. Yes.

10 Q. Okay. And then my understanding is
11 then he went on to become a principal at
12 Papadopoulos.

13 Is that consistent with your
14 understanding?

15 A. After he retired from the USGS, he
16 went to work for one consulting company, I believe
17 in Alexandria, but was not there very long, maybe
18 a year or less than a year. And then after that,
19 my understanding is he went to work for
20 Papadopoulos & Associates and worked for them at
21 least 10 years before fully retiring. I don't
22 know if he was a principal or what, but he was an
23 employee certainly.

24 Q. Sure. Okay.

1 And is it right, my understanding is
2 Gordon Bennett is considered the father of
3 MODFLOW?

4 A. Ooh. He played an administrative
5 role in getting it going. I would not have called
6 him the father of MODFLOW.

7 Q. Okay.

8 A. He played a role in getting that
9 done in terms of -- I believe he had a big role in
10 hiring the two people or designating the two
11 people, Harbaugh and McDonald, to work on this,
12 and I think administratively he pushed for this to
13 be a project to get this done. So.

14 Q. So he --

15 A. But I don't believe he actually
16 worked on the development of the code.

17 Q. Understood.

A. In general, yeah.

21 Q. Okay. Do you have any opinion about
22 S.S. -- S.S. Papadopoulos & Associates?

23 MR. DEAN: Object to the form.

24 THE WITNESS: Well, I know

1 several individuals there, including
2 Stavros Papadopoulos. Most of the people
3 working there I do not know. I don't.
4 So I can't have any opinion about them or
5 their work.

6 Stavros used to work for the
7 Survey -- USGS for quite a while. He
8 left, I believe, in '79 or '80 to form
9 his own company as a consultant.

10 BY MR. ANWAR:

11 Q. Within the environmental, you know,
12 based on your experience, within the environmental
13 sort of consulting and, I guess, modeling
14 consulting community, is S.S. Papadopoulos from
15 your understanding generally considered a good
16 firm?

17 MR. DEAN: Object to the form
18 of the question. Asked and answered.

19 THE WITNESS: Well, again, I
20 think, you know, some of the people there
21 have good reputations and some of the
22 people there I don't know their
23 reputation. Most of the people there I
24 don't know anything about them.

1 BY MR. ANWAR:

2 Q. Okay.

3 A. So it's difficult to -- to say.

4 Q. Are you familiar with John Doherty?

5 A. Oh, John Doherty from Australia?

6 Q. Correct.

7 A. Yeah, I know the name. I've met him
8 certainly at professional meetings. I remember at
9 least one case at a National Ground Water
10 Association meeting where he was a guest speaker.
11 So, you know, said hello, interacted socially. I
12 know who he is, and I know, you know, kind of what
13 he's done in terms of developing the parameter
14 estimation code called PEST.

15 Q. Can you talk a little bit about
16 that, what he's done in terms of developing PEST?

17 MR. DEAN: Object to the form
18 of the question.

19 THE WITNESS: Well, I know
20 he's the principal author of the software
21 and a book that describes it. How he did
22 it I have no idea or, you know, what he
23 did specifically I have no understanding.
24 I don't know.

1 The PEST code, I know what it
2 does and I know it's -- it's generally
3 considered a state of the art software
4 tool --

5 BY MR. ANWAR:

6 Q. Understood.

7 A. -- that could be applied for ground
8 -- excuse me -- could be applied to groundwater
9 modeling problems. It's a general code that can
10 probably be applied to any modeling problem, not
11 just groundwater.

12 Q. Were you aware that John Doherty
13 also now works with S.S. Papadopoulos?

14 A. That he what?

15 Q. That he's also at S.S. Papadopoulos?

16 A. I'm not sure what you -- could you
17 repeat the question? That he was at?

18 Q. That John Doherty is now at S.S.
19 Papadopoulos?

20 A. I did not know that.

21 Q. Okay.

22 A. That he was. I knew there was some
23 linkage there and I know he had been at their
24 offices, but being -- I had no idea he worked for

1 the firm as an employee.

2 Q. Okay. And I think I might have
3 misspoke. I think you're perhaps right.

4 He used to be at S.S. Papadopoulos;
5 correct?

6 A. I don't know that.

7 MR. DEAN: Object to the form.

8 BY MR. ANWAR:

9 Q. You don't know.

10 You said --

11 A. I know he was at the -- in their
12 office.

13 Q. Okay.

14 A. I don't know what you mean by "at"
15 Papadopoulos & Associates.

16 Q. Okay. You said he used to be linked
17 to it.

18 What do you --

19 A. I know he visited there and, you
20 know, I know he -- it's my understanding or
21 recollection that he taught a short course for
22 them on the use of that, and I think he
23 collaborates or has collaborated with Matt Tonkin,
24 who is an employee of Papadopoulos & Associates,

1 but I have no direct knowledge of what they did or
2 how they did it.

3 Q. Okay. Aside from responding to
4 their opinions in this case, do you have any
5 opinion about Dr. Spiliotopoulos or Dr. Hennet?

6 A. No.

7 Q. Why don't we take a break. I think
8 this is a good place --

9 A. Good idea.

10 Q. -- to take a break. We've been
11 going over an hour.

12 THE VIDEOGRAPHER: We're going
13 off the record. The time is 11:06 AM.

14 (A recess was taken.)

15 THE VIDEOGRAPHER: Back on the
16 record the time is 11:15 AM.

17 BY MR. ANWAR:

18 Q. We are back on the record from a
19 short break.

20 Dr. Konikow, are you okay to
21 continue?

22 A. Yes.

23 Q. Okay. During the break, did you
24 speak with your -- your lawyers about the

1 substance of your testimony at all?

2 A. No.

3 Q. Okay. Before the break, we had just
4 wrapped up a conversation about John Doherty.

5 Do you recall that?

6 A. Yes.

7 Q. One other question occurred to me
8 that I wanted to ask.

9 I noticed in the documents that were
10 produced last night in response to the subpoena,
11 there was a document where you passed along
12 Doherty's -- John Doherty's contact information to
13 Mr. Dean.

14 Do you recall that?

15 A. Yes.

16 Q. Do you know, what is your
17 understanding about why you passed that contact
18 information along?

19 A. Well, I believe he asked me if I had
20 contact information --

21 Q. Okay.

22 A. -- for John Doherty, and I had some
23 information and so, you know, I sent it to him.

24 Q. Okay. Do you know what came of

1 | that?

2 A. NO.

3 Q. Okay. Have you -- when is the last
4 time you've spoken with Mr. Doherty?

5 A. Several years ago. Probably four or
6 five years ago.

7 Q. Okay. Understood.

8 A. Yeah.

9 Q. Now, we discussed earlier you served
10 on ATSDR's expert panel on the Camp Lejeune water
11 modeling; correct?

12 A. Correct.

13 Q. Okay. And there was an expert panel
14 in 2005; correct?

15 A. Correct.

16 Q. How did you come to serve on the
17 2005 expert panel?

18 A. Somebody asked me, and I would -- I
19 would guess that it was probably Morris asked if
20 I'd be interested in doing that. I don't recall
21 exactly who or when I was asked or how I was
22 asked, but I would guess it was probably Morris.

23 THE VIDEOGRAPHER: Counsel,
24 could you please put on your mic?

1 BY MR. ANWAR:

2 Q. What do you remember about the 2005
3 expert panel?

4 A. I remember they -- I think they had
5 asked us some questions in advance before meeting,
6 maybe four to six questions to get our preliminary
7 opinions. I think they had sent us some documents
8 or draft reports to review to prepare for it.

9 I remember, you know, going to
10 Atlanta. There were two days of meetings. There
11 were, you know, a fair number of people in the
12 audience, maybe -- I don't know -- 10 to 20 at
13 different times, maybe a few more.

14 I think there were probably
15 something on the order of 10 people on the expert
16 panel. May have been 12. I don't recall exactly.
17 We had meetings. We had presentations made to us
18 about what was expected of the committee.

19 And then we had technical
20 presentations from people such as Morris, Bob Faye
21 and others about the background of the situation,
22 the hydrogeologic framework, the groundwater flow
23 systems, the contaminant sources, and basically
24 everything related to that.

1 So there were technical
2 presentations. The committee members asked
3 questions. I think towards the end we met in a
4 closed session, and I believe we came to a
5 consensus of our assessments.

6 I can't recall specifically what
7 follow-up, if any, was done after the second day
8 of the meeting.

9 Q. Thank you. That's helpful.

10 Do you recall what draft documents
11 you were provided to review in advance?

12 A. I do not recall which ones, but
13 I -- I'm -- I would guess it was preliminary
14 versions of some of the reports that were
15 eventually published, but I don't recall.

16 Q. What did you understand about the
17 purpose of the ATSDR water modeling for Camp
18 Lejeune heading into the 2005 expert panel?

19 A. Well, my understanding I believe
20 then was similar to my understanding now that the
21 purpose of the modeling was to estimate what the
22 concentrations were coming out of the Water
23 Treatment Plant and going into the distribution
24 system.

1 Q. And that was in support of a
2 population level epidemiology study; right?

3 A. I knew there were epidemiological
4 studies that would be done and that, I presume,
5 would use the information from the -- from the
6 models. I have no knowledge of any of the
7 epidemiological studies, how they were done or
8 what the results were. I don't have that
9 information.

10 Q. Sure.

11 And that 2005 expert panel, that
12 took place over two days in March 2005; right?

13 A. I presume so. That sounds about
14 right.

15 And, again, the other thing I
16 believe is that it focused on the Tarawa Terrace
17 situation.

18 Q. Okay. And you said it took place in
19 Atlanta.

20 Did it take place at ATSDR's
21 facilities?

22 A. That's my recollection. That we
23 went into a CDC campus, and they brought us over
24 to an ATSDR facility, I think, but I don't recall.

1 I remember there was a gate, and we had to go in
2 and get, you know, approved to go into the
3 facility and then were directed somewhere, but I
4 don't remember those, any more details than that.

5 Q. Sure.

6 You mentioned Morris Maslia and then
7 Robert Faye, or Bob Faye.

8 Who is Bob Faye?

9 A. Bob Faye? He's a person who, when I
10 first met him, he worked for the U.S. Geological
11 Survey. I believe his position was as a regional
12 groundwater specialist, and at the time the Water
13 Resources Division of the U.S. Geological Survey
14 was divided into four regional offices.

15 The Southeast Region was
16 headquartered in Atlanta, and my recollection is
17 that for that regional office, Bob Faye was
18 considered the -- or had the position of being the
19 regional groundwater specialist.

20 So reports or any other issues
21 dealing with groundwater that came up in any of
22 the district offices in the Southeast Region, if
23 there was some issues, Bob Faye would be the
24 regional groundwater specialist is the one who

1 would assess, comment on, evaluate any problems or
2 issues.

3 Q. Understood.

4 Do you remember who any of the other
5 members of the expert panel were? The 2005.

6 A. The 2005 panel.

7 I, you know, I looked at the list of
8 members probably a week or two ago, but I
9 just -- I can't remember who was on the 2005
10 panel.

11 Q. That's okay. Fair enough. Thank
12 you.

13 You were an expert on the 2005
14 expert panel; correct?

15 A. Correct.

16 Q. Now, you mentioned it was focused on
17 ATSDR's water modeling efforts -- the 2005 panel
18 was focused on ATSDR's water modeling efforts
19 related to Tarawa Terrace; correct?

20 A. That's my understanding, yes.

21 Q. Do you recall whether there was any
22 discussion about the Hadnot Point/Holcomb
23 Boulevard modeling at that time?

24 A. Of the modeling? I doubt it, but of

1 the existence of Hadnot Point/Holcomb Boulevard,
2 I'm sure that was mentioned.

3 Q. Did you provide feedback or input
4 about the -- about ATSDR's water modeling efforts
5 related to Tarawa Terrace in 2005?

6 A. I'm sure I did.

7 Q. Do you recall what that feedback or
8 input was?

9 A. Well, specific explicit comments I
10 can't recall. I recall, you know, the -- you
11 know, I'm sure I had questions about parameter
12 values and how they did this or why they did it
13 this way. I'm sure there was a lot of questions,
14 comments and, you know, issues.

15 I know the bottom line at the end,
16 the expert peer review panel felt very positive
17 about what they were doing in the sense that I
18 think the consensus of the expert peer review
19 panel was that the work being done by ATSDR for
20 groundwater modeling flow and transport was state
21 of the art and excellent work, reliable work.

22 Q. Okay. Were there any concerns
23 expressed at the 2005 expert panel?

24 A. I'm sure there were.

1 Q. Why do you say you're sure there
2 were?

3 A. Well, our job was to critique and
4 review everything they done -- did and we would,
5 you know, question, why did you do this? Or where
6 did you get that value from? Or what's the basis
7 of this? Again, I can't recall specific
8 questions. If I thought about it, maybe I could.

9 But I know I had some concerns about
10 numerical dispersion in the transport model, about
11 the representation of model layer 1. You know, I
12 remember these were some of the specific issues
13 that concerned me before I could get any response
14 back from them, but I felt overall that they
15 addressed all of the concerns that I had.

16 Q. Do you recall if any of the other
17 members of the expert panel expressed concerns or
18 critiques about the Tarawa Terrace efforts?

19 A. I can't recall.

20 Q. Okay. Now, you also served on the
21 expert panel held by ATSDR on Camp Lejeune water
22 modeling in 2009; right?

23 A. Correct.

24 Q. Okay. And how did you come to serve

1 on the 2009 expert panel?

2 A. I assume someone asked me to serve
3 on it. I, you know, again, I -- I assume Morris
4 had some role in inviting me, but I don't know
5 that. You know, I just don't recall.

6 Q. Okay. What do you remember about
7 the 2009 expert panel?

8 A. It focused on the Hadnot
9 Point/Holcomb Boulevard areas and the models
10 developed for that area. There probably was some
11 discussion of Tarawa Terrace, but the main focus
12 was on Hadnot Point/Holcomb Boulevard.

13 I remember Mary Hill was on that
14 panel. Dave Dougherty was on that panel. But,
15 again, I looked at the names the other day and I
16 just can't remember right now who else was on it,
17 but, you know, again there were probably 10 to 12
18 experts on the panel.

19 Q. Sure.

20 And that panel took place over two
21 days in 2009?

22 A. Exactly, yes. Correct.

23 Q. Was there a Mr. Jerry Ensminger
24 on -- that participated in that expert panel?

1 A. My recollection that's the name of a
2 Marine who was -- I remember there was one Marine
3 in the audience, and he was given a chance to
4 speak. I believe that's the name that you gave,
5 but I can't -- I'm not absolutely certain.

6 Q. You said he was in the audience and
7 he was given an opportunity to speak?

8 A. That's my recollection.

9 Q. Okay. Mr. Ensminger is not a
10 modeling expert or an epidemiologist, to the best
11 of your knowledge?

12 A. Correct.

13 Q. Was there a Mr. Mike Partain that
14 attended the expert panel as well?

15 A. I don't recall that name.

16 Q. Okay. Did you provide feedback
17 about the Hadnot Point/Holcomb Boulevard modeling
18 efforts at the 2009 expert panel?

19 A. I'm sure I did. That's why I was
20 there.

21 Q. Do you recall the feedback that you
22 provided?

23 A. I know initially I came in with some
24 skepticism, which is, you know, normal in any

1 technical review, and I had some concerns about
2 how well they could define the source terms and
3 the timing. Specific comments I don't recall.

4 Q. Do you recall any comments from
5 other members on the expert panel?

6 A. Not that I -- I do not recall
7 specific comments.

8 THE VIDEOGRAPHER: Counsel, do
9 you need help with your mic?

10 MR. ANWAR: Excuse me?

11 THE VIDEOGRAPHER: Do you need
12 help with your mic?

13 MR. ANWAR: Yeah, I'm fixing
14 it.

15 THE WITNESS: I don't recall
16 specific comments of the other
17 participants off the top of my head.

18 BY MR. ANWAR:

19 Q. Okay. Were there -- do you recall
20 any critiques or concerns about performing the
21 Hadnot Point/Holcomb Boulevard water modeling?

22 A. Well, yeah. I mean, I know I had
23 some concerns but, you know, again I think they
24 addressed my concerns.

1 Q. What were your concerns?

2 A. Well, one of the concerns was
3 compared to Tarawa Terrace where there was
4 believed to be one single source of contamination
5 and its location was pretty well known and the
6 contaminant was pretty well known and the timing
7 of it was pretty well known, looking at the Hadnot
8 Point/Holcomb Boulevard, there seemed to be
9 multiple sources just spread out over the
10 industrial areas and the landfill areas and that
11 they could not be defined with the same precision
12 that the source term on the Tarawa Terrace area
13 could be defined. So this was a concern.

14 Q. Okay. Did you --

15 A. For --

16 Q. Go ahead.

17 A. I was going to add that, you know,
18 for both of them, there was, you know, no
19 observations of concentration for a period of
20 years before the problem became recognized, you
21 know, that's an issue that has to be addressed.

22 Q. Sure.

23 There -- there were observed
24 contamination levels or samples taken in 1982 and

1 1985 at Camp Lejeune; right?

2 A. I believe so, and maybe, you know,
3 in between. There may have been some '83, '84 I
4 believe, but I don't recall the exact dates. But
5 that sounds about right.

6 Q. Okay. And the ATSDR modeling
7 efforts related to Tarawa Terrace and Hadnot Point
8 and Holcomb Boulevard, they were attempting to
9 reconstruct historical contamination levels,
10 monthly contamination levels dating back to 1953;
11 correct?

12 MR. DEAN: Object to the form.

13 THE WITNESS: 1953 for Tarawa
14 Terrace, but I believe earlier for Hadnot
15 Point and Holcomb Boulevard.

16 BY MR. ANWAR:

17 Q. And the earliest available data
18 during that period was 19 -- and when I say
19 "available data" what I'm specifically referring
20 to is observed contaminant concentration levels of
21 sampling data.

22 The earliest data available during
23 that time was 1982; correct?

24 A. Yes, that's the observed, but I also

1 view the assumption at the start of the simulation
2 before there was any as equivalent to an observed
3 level of no contaminant in the aquifer as a known
4 condition. Even though there were no samples that
5 showed it was zero before 1953, that seemed like a
6 pretty reliable and accurate assumption.

7 Q. What is the assumption that you're
8 referring to?

9 A. That you have to -- in developing
10 the model -- and they started with Tarawa Terrace
11 in 1953. To solve any governing partial
12 differential equation, which is what the numerical
13 models do, you have to define boundary conditions
14 and initial conditions.

15 Definition of the initial conditions
16 for the solute transport model are the
17 concentration distribution of the solute of
18 concern at times zero, which would be 1953.

19 And inherently there's an assumption
20 that it was zero before any contaminant was
21 introduced, and that is a very reasonable, logical
22 assessment of the initial condition in terms of
23 what the concentration distribution was at that
24 time, which is zero.

1 Q. Understood.

2 But for the period prior to 1982,
3 there were no historical observed concentration
4 level data; correct?

5 MR. DEAN: Object to the form.

6 THE WITNESS: Not that I'm
7 aware of.

8 BY MR. ANWAR:

9 Q. Besides serving on these two expert
10 panels, the one in 2005 focused on Tarawa Terrace
11 and the one in 2009 more focused on Hadnot
12 Point/Holcomb Boulevard, did you contribute or do
13 any work related to ATSDR's water modeling efforts
14 for Camp Lejeune?

15 A. No.

16 Q. I saw that you're not listed as an
17 author on any of the reports; right?

18 A. Correct.

19 Q. You weren't involved in writing the
20 reports?

21 A. Not at all.

22 Q. And you didn't perform any of the
23 data collection or the field testing; right?

24 A. No, I did not.

1 Q. Okay. Have you ever visited Camp
2 Lejeune?

3 A. No, I have not.

4 Q. And earlier in your deposition I
5 think we discussed that at that time you were --
6 that you served on the -- the two expert panels,
7 you were employed by the U.S. Geological Survey;
8 correct?

9 A. Yes.

10 Q. And so other than your salary as an
11 employee of the U.S. Geological Survey, you were
12 not compensated at all to participate in the --
13 the 2005 or 2009 panels; correct?

14 A. That's correct.

15 MR. ANWAR: Okay. I'm going
16 to mark an exhibit. I'm handing to the
17 court reporter what is being marked as
18 Exhibit 7.

19 (Document marked for
20 identification as Konikow Exhibit 7.)

21 MR. DEAN: Can we agree that
22 this is not the entire book? Just select
23 to.

24 MR. ANWAR: We can agree this

1 is not the entire book.

2 BY MR. ANWAR:

3 Q. I've handed you an exhibit that I've
4 marked as Exhibit 7. This is -- this is an
5 excerpt from a book entitled "The Handbook of
6 Groundwater Engineering"; correct?

7 A. Yes.

8 Q. And you're familiar with this book;
9 right?

10 A. I haven't looked at it in years, but
11 I was a coauthor of that chapter. So yes.

12 Q. Okay. The book itself was published
13 in 1999; right?

14 A. (Reviews document.)

15 It says 19 -- yeah, it says
16 copyright 1999.

17 Q. Okay. And you just mentioned you
18 coauthored that chapter.

19 You coauthored Chapter 20 on
20 "Groundwater Modeling"; right?

21 A. Yes.

22 Q. Okay. And you coauthored it with a
23 gentleman named Thomas E. Reilly?

24 A. Correct.

1 Q. Who is Thomas E. Reilly?

2 A. Tom was a groundwater scientist or
3 engineer that worked with the U.S. Geological
4 Survey. I knew him as a colleague from the USGS.
5 We were in the -- we overlapped in the same office
6 for a while in the -- I think it's called the
7 Office of Groundwater, which was kind of a
8 headquarters quality assurance type of group.

9 Tom moved -- he had worked on Long
10 Island, New York in the Long Island office for
11 many years. Then he moved to Reston to join us
12 headquarters group. Then I left that to join the
13 research program, and several years later Tom did
14 the same thing and was in the research program.
15 We were colleagues there. Then he moved back into
16 the Office of Groundwater after a year or two in
17 the research program.

18 So, you know, we were colleagues,
19 you know, knew each other, and I had invited him
20 to help me prepare this chapter on "Groundwater
21 Modeling." He had more expertise on finite
22 element methods than I did and I thought he was,
23 you know, well-known and well-rounded in
24 groundwater modeling technique. I thought it

1 would be very beneficial to have him as a
2 coauthor.

3 Q. Understood.

4 And the words in this chapter in
5 Chapter 20 are yours and his; right?

6 A. Yes.

7 Q. Okay. I wanted to ask you a few
8 questions about Section 20.1 in Chapter 20, which
9 is the Introduction.

10 The opening line in the chapter
11 reads:

12 "Effective management of groundwater
13 requires the ability to predict subsurface flow
14 and transport of solutes, and the response of
15 fluid and solute flux to changes in natural or
16 human-induced stresses."

17 Did I -- did I read that correctly?

18 A. Yeah. Yeah.

19 Q. What do you mean by "effective
20 management of groundwater"?

21 A. Well, I mean, groundwater is a
22 resource. It's, you know, used to the benefit of
23 society, also to the benefit of individuals and
24 benefit of cities, benefit of factories, benefit

1 of agricultural. You know, there's just multiple
2 uses.

3 It's a resource that should be
4 managed and it's a resource that in many cases
5 throughout the U.S. and the rest of the world is
6 not managed at all. Because people -- a landowner
7 could drill a well and pump out as much water as
8 they want, in some cases without anyone overseeing
9 their use of the resource.

10 In the U.S. that varies greatly by
11 state to state. In some areas, particularly if
12 there have been some problems or limitations on
13 the use, it's been overdeveloped, then they form
14 management districts or laws are implemented in a
15 state or in a county to try to, well, in effect,
16 manage the resource and try to assure that it
17 lasts longer as a resource, as a usable resource
18 than it would if there was no limitations on
19 development.

20 So by "effective management," we're
21 really implying that there is some management
22 structure governing the use of groundwater that's
23 there for basically the benefit of society and the
24 common good. And, you know, I guess in our

1 opinion, the effective management, management that
2 is efficient and effective in trying to assure the
3 sustainability of a groundwater resource in an
4 area is just a necessary and valuable imposition
5 of some controls on the use of the resource, but
6 it's not done everywhere.

7 Q. Understood.

8 Does management entail planning?

9 A. Management should involve planning,
10 thinking ahead, yeah. If they're not thinking
11 ahead, then they're not doing a good job managing
12 it.

13 Q. And that I think you mentioned -- I
14 can't recall if it was scarcity or conservation of
15 water.

16 Is it management of?

17 A. Well, I think I put it in the terms
18 of sustainability.

19 Q. Sustainability, correct.

20 A. And, you know, that's easier to do
21 in some areas than in others.

22 Q. Sure.

23 If you turn the page to Chapter 20.2
24 on page 20-2, it's a subsection entitled "Models";

1 right?

2 A. Okay.

3 Q. And the first couple sentences
4 there:

5 "The word 'model' has so many
6 definitions and so overused that it's sometimes
7 difficult to discern its meaning."

8 And then there's a citation to you
9 and I think Fred Bredehoeft?

10 A. Bredehoeft. Bredehoeft.

11 Q. Bredehoeft.

12 And then the next line:

13 "A model is perhaps most simply
14 defined as a representation of a real system or
15 process. A conceptual model is a hypothesis for
16 how a system or process operates."

17 Did I read that correctly?

18 A. Yes.

19 Q. Okay. And so a model is a
20 simplified representation of a real world system
21 or process; that's what you're saying there?

22 A. That's what we said.

23 Q. Okay. And a conceptual model is a
24 hypothesis for how a system or process operates;

1 right?

2 A. In effect. It's a -- it's a verbal
3 description of your understanding.

4 Q. And the --

5 MS. BAUGHMAN: Were you
6 finished, Dr. Konikow?

7 THE WITNESS: Well, I was just
8 going to add: As a verbal description,
9 it could be either qualitative or
10 quantitative.

11 BY MR. ANWAR:

12 Q. Okay. And the start of the next
13 paragraph there it says:

14 "Most groundwater models in use
15 today are deterministic mathematical models."

16 Right?

17 A. That's what it says, yes.

18 Q. Okay. What -- what is a
19 deterministic model?

20 A. A deterministic model is one in
21 which the solution, the result is, in effect,
22 predetermined by the solution to a governing
23 equation. You have a mathematical equation that
24 describes quantitatively your understanding of the

1 processes that govern, let's say, groundwater
2 flow, and to solve the differential equation, you
3 need to define boundary conditions and initial
4 conditions and the solution to that, the results.

5 It's not random. It's predetermined
6 by the parameters you put in and the nature of the
7 equation and your definition of initial and
8 boundary conditions and, you know, if one person
9 does it here and another person does it there, if
10 they have all the same parameters and the same
11 equation, they should get the same results.

12 Q. Got it.

13 The next line in that second
14 paragraph says:

15 "Deterministic models are based on
16 conservation of mass, momentum, and energy and
17 describe cause and effect relationships."

18 Right?

19 A. Yes.

20 Q. Okay. And what does "conservation
21 of mass, momentum, and energy" mean?

22 A. Okay. These are basic thermodynamic
23 principles that, you know, if you have a certain
24 volume of water coming into a box, or an aquifer

1 or some kind of element, masses can serve that's
2 neither created nor disturbed, destroyed, except
3 for radioactive constituents and, you know, what
4 goes in has to be balanced by what comes out or
5 what the mass and storage in that unit changes.

6 Q. Does that mean that in a
7 deterministic model, the mass, momentum, and
8 energy remain constant throughout time?

9 A. No.

10 Q. Okay.

11 A. It just means that, you know, if you
12 add mass to the system at some later time, then it
13 all has to be balanced.

14 Q. I got you.

15 A. Yeah.

16 Q. So if we turn to -- well, it's on
17 the same printed page, but the next page of the
18 book is subsection 20.3 Flow and Transport
19 Processes.

20 A. Yes.

21 Q. I wanted to ask you about the --
22 that first line says or the first line of the
23 second paragraph -- paragraph:

24 "The purpose of a model that

1 simulates solute transport in groundwater is to
2 compute the concentration of a dissolved chemical
3 species in an aquifer at any specified time and
4 place."

5 Is that right?

6 A. I believe so.

7 Q. Okay. And then if we jump ahead a
8 little bit to the paragraph at the end of that
9 section starting with "The subsurface," it says:

10 "The subsurface environment
11 constitutes a complex, three-dimensional
12 heterogeneous hydrogeologic setting. This
13 variability strongly influences groundwater flow
14 and transport, and such a reality can be described
15 accurately only through careful hydrogeologic
16 practice in the field."

17 Did I read that correctly?

18 A. Yeah. The word "heterogenous" was
19 on the first line.

20 Q. Oh, hetero. Yeah, heterogeneous.

21 A. Yes, you read it correctly.

22 Q. Okay. These are your words, so
23 you'll agree with that; right?

24 A. Yes.

1 Q. Okay. And then "However" the next
2 sentence in that same paragraph.

3 "However, regardless of how much
4 data are collected, uncertainty always remains
5 about the properties and boundaries of the
6 groundwater system of interest."

7 Why -- why does uncertainty always
8 remain?

9 A. Well, the subsurface environment,
10 basically the geologic framework of an aquifer due
11 to geologic processes, its properties and
12 characteristics of permeability, porosity and so
13 on just vary in space because of the geologic
14 processes that led to the deposition of material
15 and its geologic modification subsequent to its
16 deposition, its burial by under sediments and so
17 on.

18 And these are complex patterns and
19 they're underground. You can't look at them
20 directly. So there you could use geophysical
21 methods to try to find out different
22 characteristics, change in space, but there's
23 limitations to how accurate that is.

24 You use wells to observe at a point,

1 but whatever you define at that point, the
2 properties could be a little different 10 feet
3 away or maybe even more than a little different.

4 In other words, it's out of sight
5 out of the ability of us to see underground to
6 completely characterize all the properties of the
7 system. It's, you know, it just can't be done
8 with present -- certainly not with present
9 technology.

10 Q. Understood.

11 A. And so we do the best we could,
12 interpolate between points where we have more
13 data, and then build that into a model.

14 Q. And there's no way to create a model
15 that perfectly recreates reality; right?

16 A. That's my belief.

17 Q. Okay. And you just explained it,
18 but a large part of that is because there are
19 aspects of the subsurface that we don't know
20 about; correct?

21 MR. DEAN: Object to form.

22 THE WITNESS: We --

23 MR. DEAN: You can continue.

24 THE WITNESS: Yeah.

1 That we can't observe directly
2 within any kind of feasible economic
3 framework. I mean, if you drill more and
4 more wells to observe more and more
5 spaces, pretty soon the wells themselves
6 are increasing the porosity of the
7 aquifer.

8 So there's a limit to how much
9 we could do, and certainly it's expensive
10 to drill one well. So you never have a
11 budget to drill an infinite number of
12 observation wells.

13 BY MR. ANWAR:

14 Q. And are subsurface conditions -- I
15 guess for lack of a better way of saying this, are
16 subsurface conditions changing based on sort of
17 the environmental conditions surrounding them?

18 A. The hydraulic properties very rarely
19 would change in time on a human time frame. That
20 just doesn't happen. The hydraulic conditions in
21 terms of pressure distributions and water levels,
22 those certainly can change quickly.

23 Q. Okay. How groundwater modeling and
24 transport is typically used for planning and

1 management purposes; right?

2 MR. DEAN: Object to form.

3 THE WITNESS: Can you repeat
4 that?

5 BY MR. ANWAR:

6 Q. Groundwater -- groundwater modeling
7 is typically used for planning and management
8 purposes; right?

9 MR. DEAN: Same objection.

10 THE WITNESS: Well, typical
11 uses of groundwater models? I wouldn't
12 say it's typical for that. Models are
13 used for management purposes, but they're
14 used for many other purposes, and I don't
15 know which purpose is more typical.

16 BY MR. ANWAR:

17 Q. What are some of the management
18 purposes that models are used for?

19 A. I think the first highest level use
20 is to understand the system to help. Good
21 management of the system requires that you
22 understand the system and understand which way
23 groundwater is flowing, what the head distribution
24 is, and how the whole system operates. How to

1 predict the effects of drilling a new well and
2 pumping it at a specified rate might impact other
3 users. It might impact the water table and the
4 sustainability of the resource. The model allows
5 you to do that in a quantitative way.

6 Q. And to understand the system, that
7 could be one of the purposes of sort of a model or
8 uses of a model would be to project water needs in
9 the future for -- for agriculture; right?

10 A. Well, not to project water needs,
11 but to project the impacts of water use. You
12 wouldn't use the model -- a groundwater model to
13 predict water use. You would use it -- you would
14 predict water use some other way based on
15 economic, climate, whatever.

16 There you would estimate water use,
17 and then you could say, what would happen to the
18 system if this water use is implemented in the
19 future? And the model could then help you assess
20 what the impacts of a proposed water use would be.

21 Q. Okay. That's really helpful.

22 And then a model can also be used to
23 estimate the movement of contaminants for
24 remediation efforts; right?

1 A. Certainly.

2 Q. Now, I'd like you to take a look at
3 your rebuttal report. It's Exhibit 2.

4 Okay. So looking at the first
5 paragraph under Introduction on page 1, it says
6 there that:

7 "ATSDR prepared reports describing
8 models developed to stimulate groundwater flow and
9 contaminant transport at two areas of Camp
10 Lejeune, North Carolina: Tarawa Terrace and then
11 Hadnot Point/Holcomb Boulevard area."

12 Correct?

13 A. Yes.

14 Q. And when we're talking about ATSDR's
15 Camp Lejeune water modeling efforts -- I think
16 this has been clear already, but I just want to
17 confirm.

18 When we're talking about ATSDR's
19 Camp Lejeune water modeling efforts, we're really
20 talking about two separate water models; correct?

21 A. Correct.

22 Q. ATSDR completed a water model
23 related to Tarawa Terrace; right?

24 A. Yes.

1 Q. And my understanding, at least of
2 the last report, it was completed around 2009.

3 Is that consistent with your
4 understanding?

5 A. I believe so. I don't remember the
6 dates on the reports, but that sounds about right.

7 Q. Okay. And for Tarawa Terrace, ATSDR
8 performed a groundwater model using MODFLOW;
9 right?

10 A. Correct.

11 Q. And then they performed a fate and
12 transport model using MT3DMS; right?

13 A. Yes.

14 Q. Is there -- the general uncertainty
15 that we just discussed in terms of flow and
16 transport processes, does that exist for
17 groundwater models as well?

18 MR. DEAN: Objection.

19 BY MR. ANWAR:

20 Q. For -- for flow models?

21 MR. DEAN: Object to the form.

22 THE WITNESS: Well,
23 groundwater flow models such as
24 MODFLOW --

1 BY MR. ANWAR:

2 Q. Yeah.

3 A. -- assume that the changes can be
4 described by a governing equation that is fairly
5 standard, well accepted by scientists and
6 engineers. You know, it's pretty common.

7 Parameters values, in other words,
8 the equation has coefficients in it, and those
9 coefficients need to be described in order to
10 solve the equation. Those coefficients include
11 hydraulic properties such as hydraulic
12 conductivity, the saturated thickness, how you
13 discretize the system, storage coefficients or
14 specific yields. If it's a transient flow
15 problem.

16 But, you know, one of the primary is
17 hydraulic conductivity, but you could also
18 sometimes refer to as transmissivity if you
19 account for the saturated thickness of the layer.

20 So you need to describe these and,
21 again, as with any other geologically based
22 parameter or property, yes, there is uncertainty.

23 Q. And I guess I was wondering.

24 When you -- so for the Tarawa

1 Terrace model, MODFLOW was used for the
2 groundwater flow model and MT3DMS were used -- was
3 used for the fate and transport model and then
4 they were linked together; correct?

5 A. Well, yeah, there's a linkage
6 between the two, but it's not necessarily, you
7 know, one integrated model.

8 Generally what is done, at least for
9 those codes, for MT3D, is you run the flow model
10 first and you generate a very large file that has
11 all the heads and specific discharges, all the
12 fluxes, and then you run -- afterwards you run
13 MT3D and the MT3D reads the file. There's some
14 linkage file that connects MT3D with the data that
15 was produced by the flow model.

16 Q. I guess my -- my question is that if
17 you use MODFLOW, a MODFLOW-based flow model and
18 with an MT3D-based flow and transport model, with
19 both models having some level of uncertainty, when
20 you use them -- when you use them together, does
21 that uncertainty sort of -- does it become
22 cumulative?

23 A. No, I wouldn't say that, but I would
24 correct you. MT3D is not a flow model.

1 Q. Oh, I'm sorry.

2 A. So it's just a solute transport
3 model. It uses the flows or fluxes that are
4 output or calculated by MODFLOW.

5 Q. Okay. I think that's what I meant
6 was it's a transport model; correct?

7 A. It's a transport model, and I would
8 not say that the, you know, uncertainty is
9 cumulative in any way.

10 Q. Okay. And for the Hadnot
11 Point/Holcomb Boulevard water modeling effort,
12 that was separate from Tarawa Terrace; right?

13 A. That's my understanding.

14 Q. Okay. And that was completed around
15 2013; right?

16 A. That's my understanding.

17 Q. And for that -- for Hadnot
18 Point/Holcomb Boulevard, ATSDR again used MODFLOW
19 for the groundwater flow model; correct?

20 A. I believe they used a newer version
21 of MODFLOW than was used in the Tarawa Tara
22 list -- Terra -- Tarawa Terrace model.

23 Q. Okay. And for the transport model,
24 they used MT3DMS --

1 A. Yes.

2 Q. -- again; right?

3 A. Yes.

4 Q. And then this time they also used a
5 water distribution model EPANET to simulate
6 intermittent connections between Hadnot Point and
7 Holcomb Boulevard; right?

8 A. Yes.

9 Q. Okay. To the best of your
10 knowledge, did ATSDR perform water models for any
11 other water distribution systems at Camp Lejeune?

12 A. At Camp Lejeune? Not that I'm aware
13 of.

14 Q. Okay. Now, looking at your report,
15 going back to your report, the next line after
16 that first sentence we -- we just discussed is:

17 "Their use of the models was
18 innovative in the sense that instead of a typical
19 use of a groundwater model to predict future
20 behavior, they used the model to 'predict' how the
21 system evolved in the past (before concentration
22 observations were made) from a known state (an
23 initial condition), in which no contaminants were
24 present, to a contaminated aquifer with a mapped

1 distribution in the early to mid-1980s when
2 contamination was observed at a number of
3 locations (wells, soils samples, and water
4 treatment plants)."

5 Did I read that correctly?

6 A. Yes.

7 Q. My question was about -- I guess my
8 question was a moment ago I asked you whether
9 models are typically used -- I guess groundwater
10 flow and transport models are typically used for
11 planning or groundwater -- groundwater management
12 purposes, and I think you said you weren't sure
13 whether they were used typically or not typically
14 for that purpose.

15 Is that a fair assessment?

16 A. Yeah, it's --

17 MR. DEAN: Hold on.

18 Object to form of the
19 question. Misstates his prior testimony.

20 BY MR. ANWAR:

21 Q. Was that a fair characteristic
22 -- characterization of your testimony?

23 A. Yes.

24 Q. Okay. And so here you say that the

1 ATSDR models were "innovative in the sense that
2 instead of a typical use of a groundwater model to
3 predict future behavior."

4 Groundwater and transport models are
5 typically used to predict future behavior; right?

6 A. Very often or to help understand
7 present behavior.

8 Q. And the ATSDR model, you know, here
9 in your report is innovative in the sense that it
10 was being used to predict past concentration
11 levels for which real world observed concentration
12 level data wasn't available; correct?

13 MR. DEAN: Object to the form.

14 THE WITNESS: Well, the
15 objective -- primary objective seemed to
16 be that historical reconstruction.

17 That's, I'd say, typically not the main
18 objective, but I didn't mean to imply
19 that -- that what you call historical is
20 never done. It's actually commonly done,
21 but not as the main purpose of the model.

22 BY MR. ANWAR:

23 Q. Can you elaborate on that a little
24 bit? When you say you didn't mean to imply that

1 it's not commonly done but not the main purpose of
2 the model, what do you mean by that?

3 A. What I mean is, for the Tarawa
4 Terrace, it seemed like a main objective in terms
5 of computing the concentrations over time. A main
6 focus was on reconstructing that concentration
7 distribution in that period in which there were no
8 data prior to 1982.

9 That the solution of the governing
10 equation for a period in which there's no
11 observation is actually very common in transport
12 models -- in contaminant transport models because
13 it's very common that there's a period of record
14 in which there is no observations.

15 For groundwater contamination
16 problems, people generally are not aware it's a
17 problem until it shows up someplace where it
18 doesn't belong.

19 A well is contaminated. Someone is,
20 you know, drinking. Then all of a sudden people
21 recognize a problem. Then they start making
22 measurements and observations, but groundwater
23 moves slowly. So that could be 10, 20, or 30
24 years before the problem is recognized and

1 observations are made.

2 If you're going to model that
3 system, you have to start back at time zero before
4 any contaminants are introduced, and so it's very
5 common that, you know, you would be doing
6 essentially the same thing, but it's very often
7 not called historical reconstruction.

8 Q. Understood.

9 The -- I think earlier in your
10 deposition we discussed that the ATSDR models were
11 attempting to reconstruct population level monthly
12 contaminant concentrations for use in an EPI
13 study; right?

14 MR. DEAN: Object to the form
15 of the question.

16 THE WITNESS: Well, I mean, I
17 don't know about population level
18 studies. I'm not even sure what that
19 means.

20 But we were aware that the
21 groundwater modeling would be used for
22 epidemiological studies.

23 BY MR. ANWAR:

24 Q. Okay. And I think I misspoke.

1 What I meant to say was the ATSDR
2 models were used to reconstruct or estimate past
3 monthly concentration levels to support a
4 population level epidemiological study; right?

5 MR. DEAN: Object to the form
6 of the question.

7 THE WITNESS: Yeah. Well,
8 everything you said after "support" I'm
9 not sure about, but yes, the models were
10 used to reconstruct the concentrations
11 distributions throughout the aquifer
12 prior to 1982.

13 BY MR. ANWAR:

14 Q. Okay. Are you aware of any other
15 models besides AT -- or strike that.

16 Are you aware of any models
17 attempting to reconstruct historical contaminant
18 concentration levels for the purpose of
19 determining exposure in individuals?

20 MR. DEAN: Object to the form.

21 Are you talking about Camp
22 Lejeune or just in general?

23 MR. ANWAR: I asked about any
24 models.

1 MR. DEAN: Okay.

2 BY MR. ANWAR:

3 Q. Are you aware of any modeling
4 attempting to reconstruct historical contaminant
5 concentration levels for the purpose of
6 determining exposure in human individuals in real
7 life?

8 A. For that purpose in real life? No.
9 I mean, I would say modeling at the WIPP site was
10 used to predict future exposure, and then they
11 were health studies or assessments made on that,
12 but that was all hypothetical a thousand years in
13 the future. But that's what the modeling was
14 done. It was related to exposure of a future
15 farmer living downstream. So yes, that was done
16 there.

17 I'm aware of many studies where that
18 historical reconstruction was done but not for the
19 purpose of exposure.

20 Q. Okay. And during that WIPP study,
21 did that model into the future actually simulate
22 estimated concentration levels?

23 A. Yes.

24 Q. It did?

1 A. Yes, but not -- the model itself did
2 not get into the health and exposure issue. It
3 just computed the concentrations how they would
4 spread under a hypothetical breach of the
5 repository.

6 Q. And then what was that information
7 used for?

8 A. As part of a safety assessment for
9 the proposed radioactive repository, and all of
10 those analyses were included in the safety
11 assessment that was submitted to EPA to get an
12 operational license for the site, and that
13 approval was granted somewhere in the mid-1990s or
14 late 1990s.

15 Q. Okay. Now, jumping back to
16 Exhibit 7, which is Chapter 20 of your book.
17 Yeah, Chapter 20. Your Chapter 20 of the book
18 that we looked at.

19 I'd like to ask you a few questions
20 about section 20.6.

21 A. Okay.

22 Q. That subsection is titled "Model
23 Design, Development, and Application"; right?

24 A. Yes.

1 Q. And the first sentence there in your
2 book -- excuse me -- in your chapter that you
3 coauthored states:

4 "The first step in model design and
5 application is to define the nature of the problem
6 and the purpose of the model."

7 Right?

8 A. Yes.

9 Q. Okay. And those are your words;
10 right?

11 A. Well, mine and Tom Reilly's.

12 Q. Okay. But you don't disagree with
13 those words; right?

14 A. Nope.

15 Q. Okay. Why is defining the nature of
16 the problem and the purpose of the model the first
17 step?

18 A. Well, you have to know the nature of
19 problems to know before you decide what the best
20 form of a model is to simulate it. Knowing the
21 purpose of the model, what it would be used for,
22 helps you assess what factors should be included
23 and what could be safely ignored.

24 Q. Understood.

1 And so if we go on, it says:
2 "Although this may seem obvious, it
3 is important -- it is an important first step that
4 is sometimes overlooked in a hasty effort to take
5 action. This step is closely linked with the
6 formulation of a conceptual model, which again is
7 required prior to development of a mathematical
8 model."

9 Did I read that correctly?

10 A. Yes.

11 Q. Okay. And those are words that you
12 coauthored; right?

13 A. Excuse me?

14 Q. Those are words that you coauthored;
15 right? Those are your words; right?

16 A. Yes.

17 Q. Okay. And you still agree with
18 what's said there; correct?

19 A. I believe so. Yes.

20 Q. And then if we jump to the end there
21 or if we go a little further down in the
22 paragraph, starting with the sentence that says
23 "Good judgment."

24 "Good" -- do you see where I'm at?

1 A. Yeah, I could see it.

2 Q. Okay.

3 "Good judgment is required to
4 evaluate and balance the trade-offs between
5 accuracy and cost, with respect to model
6 development, model use, and data requirements.
7 The key to efficiency and accuracy in modeling a
8 system probably is more affected by the
9 formulation of a proper and appropriate conceptual
10 model than by the choice of a particular numerical
11 method or code."

12 Did I read that correctly?

13 A. You did.

14 Q. Okay. And do you agree with that
15 statement?

16 A. Yes.

17 Q. Okay. And in particular, the
18 key -- what it says there is that the key to
19 efficiency and accuracy in a modeling system is
20 more affected by the formulation of a proper and
21 appropriate conceptual model; right?

22 A. Yes.

23 MR. ANWAR: Okay. I'm going
24 to hand -- I'm going to hand you what I

1 am marking as Exhibit 8.

2 (Document marked for
3 identification as Konikow Exhibit 8.)

4 BY MR. ANWAR:

5 Q. Exhibit 8 is the "Chapter A: Summary
6 of Findings" for ATSDR's Tarawa Terrace water
7 model; correct?

8 A. Yes.

9 Q. Okay. If you turn to -- it's page
10 Roman numeral III. Just a couple pages in. Under
11 the Foreword.

12 A. Yes.

13 Q. You see that?

14 A. Yes.

15 Q. It says:

16 "ATSDR, an agency of HHS, is
17 conducting an epidemiological study to evaluate
18 whether in utero and infant (up to 1 year of age)
19 exposures to volatile organic compounds in
20 contaminated drinking water at U.S. Marine Corps
21 Base Camp Lejeune, North Carolina, were associated
22 with specific birth defects and childhood cancers.
23 The study includes births occurring during the
24 19 -- during the period 1968 to 1985 to women who

1 were pregnant while they resided in family housing
2 at the base."

3 Did I read that correctly?

4 A. Yes.

5 Q. And as we discussed before, the
6 ATSDR's water model for Tarawa Terrace was
7 developed to obtain estimates of historical
8 exposure for the EPI study that they were
9 performing --

10 MR. DEAN: Object.

11 BY MR. ANWAR:

12 Q. -- correct?

13 MR. DEAN: Object to the form
14 of the question.

15 THE WITNESS: Well, I don't
16 know that it was developed that the
17 models would calculate exposures. The
18 models would calculate the concentration
19 distribution in time and space.

20 BY MR. ANWAR:

21 Q. The -- if we go to the next
22 paragraph just underneath, it says:

23 "Historical exposure data needed for
24 the epidemiological case-control study are

1 limited. To obtain estimates of historical
2 exposure, ATSDR is using water-modeling techniques
3 and the process of historical reconstruction."

4 Did I read that correctly?

5 A. You did.

6 Q. And that was the purpose of ATSDR's
7 model for Tarawa Terrace; correct?

8 A. Well, yeah. I think the next
9 sentence that you didn't read is critical also.

10 These -- these methods, the water
11 modeling techniques, "are used to quantify
12 concentrations of particular contaminants in
13 finished water and to compute the level and
14 duration of human exposure to contaminated
15 drinking water."

16 So I think that's a key part of it.

17 Q. Sure.

18 But that -- that was the purpose?

19 A. Yeah.

20 Q. What we both read; correct?

21 A. Yes. Yes.

22 Q. Okay. Now, if you turn to
23 page -- well, let me -- let me -- one question
24 before we turn the page.

1 Per the first paragraph, the EPI
2 study that was being performed was for the period
3 between 1968 and 1985; correct?

A. Apparently, yes.

5 Q. Okay. And if we turn the page to
6 A98.

7 A. To which page?

8 Q . A98 .

9 A. A98.

10 Q. This is a -- this is part of a Q&A
11 about the Tarawa Terrace model and there's a
12 question there. The last question on A98 says:

Did I read that correctly?

21 A. Yes.

Q. Okay. And the answer is:

23 "ATSDR's exposure assessment cannot
24 be used to determine whether you, or your family,

1 suffered any health effects as a result of past
2 exposure to PCE-contaminated drinking water at
3 Camp Lejeune."

4 Did I read that correctly?

5 A. Yes.

6 Q. And it goes on to say:

7 "The study will help determine if
8 there is an association between certain birth
9 defects and childhood cancers among children whose
10 mothers used this water during pregnancy.
11 Epidemiological studies such as this help improve
12 scientific knowledge of the health effects of
13 these chemicals."

14 Did I read that correctly?

15 A. Yes.

16 Q. And, again, per this information
17 here, the model -- the -- the estimated monthly
18 concentration -- contaminant concentration levels
19 were for the purpose of epidemiological studies;
20 correct?

21 MR. DEAN: Object to the form
22 of the question.

23 And also note you didn't read
24 the entire answer to the question into

1 the record. You only chose a few select
2 sentences.

3 MR. ANWAR: You can the --
4 correct.

5 THE WITNESS: Could you
6 repeat the question?

7 BY MR. ANWAR:

8 Q. Sure.

9 The -- it's what we -- what we've
10 been talking about, that the purpose of the
11 simulated monthly estimated contaminant
12 concentrations produced by the Tarawa Terrace
13 model, those were intended to be used for an EPI
14 study, right, that ATSDR was performing?

15 MR. DEAN: Object to the form
16 of the question.

17 You've asked this same
18 question 50,000 times already. I'm not
19 going to instruct the witness not to
20 answer it but --

21 MR. ANWAR: Kevin, I'm going
22 to ask you to limit.

23 MS. HURT: -- you keep asking
24 the same question 40 different times, and

1 you're looking for a specific response
2 you're not getting. So I would --

3 BY MR. ANWAR:

4 Q. The answer is correct. It was used
5 for an EPI study; right?

6 MR. DEAN: Object to the form
7 of the question.

8 BY MR. ANWAR:

9 Q. It was intended for use for an EPI
10 study; right?

11 MR. DEAN: Object to the form
12 of the question.

13 THE WITNESS: I believe so.

14 BY MR. ANWAR:

15 Q. Okay. As you sit here today, as
16 someone that has reviewed all of the reports for
17 Tarawa Terrace, the Tarawa Terrace model, can you
18 point me to anywhere in the ATSDR report stating
19 that the TT model, the Tarawa Terrace model was
20 intended to be used for exposure -- exposure
21 determinations in individuals in the real world?

22 MR. DEAN: Object to the form
23 of the question.

24 This witness is not qualified,

1 and he's told you that, as an
2 epidemiologist.

3 THE WITNESS: The answer
4 would be no.

5 BY MR. ANWAR:

6 Q. Okay. And can you point me to
7 anywhere in the ATSDR reports stating that the
8 Tarawa Terrace model was intended to be used in
9 litigation as part of a causation analysis for
10 individual plaintiffs?

11 MR. DEAN: Object to the form
12 of the question.

13 THE WITNESS: I do not recall
14 seeing any mention of litigation in
15 there.

16 BY MR. ANWAR:

17 Q. Okay.

18 MR. DEAN: It was an
19 independent study performed by the United
20 States government.

21 MR. ANWAR: I am going to hand
22 you what I'm marking as Exhibit 9.

23 (Document marked for
24 identification as Konikow Exhibit 9.)

1 BY MR. ANWAR:

2 Q. And if you turn to page Roman
3 numeral III again, the Foreword. The almost
4 identical language is included as in the Tarawa
5 Terrace report, and I'll read it. It says:

6 ATSDR "is conducting epidemiological
7 studies to evaluate the potential for health
8 effects from exposures to volatile organic
9 compounds (such as PCE, TCE, and benzene) in
10 drinking (finished) water at U.S. Marine Corps
11 Base Camp Lejeune, North Carolina. Historical
12 exposure data needed for the epidemiological
13 studies are limited. To obtain estimates of
14 historical exposures, ATSDR is using
15 water-modeling techniques and the process of
16 historical reconstruction to quantify
17 concentrations of particular contaminants in
18 finished water and to compute the level and
19 duration of human exposure to contaminated
20 drinking water."

21 Did I -- did I read that correctly?

22 A. Yes.

23 Q. Okay. And again here in the
24 Foreword, it's stating that the historical

1 exposure data needed for epidemiological studies;
2 correct?

3 MR. DEAN: Object to the form
4 of the question.

5 THE WITNESS: Can you repeat
6 the question?

7 BY MR. ANWAR:

8 Q. It's stating here historical
9 exposure data is needed for the epidemiological
10 studies that ATSDR is performing; correct?

11 A. Yeah.

12 Q. Okay. And that was the purpose of
13 the Hadnot Point/Holcomb Boulevard model; correct?

14 MR. DEAN: Object to the form
15 of the question. Mischaracterizes prior
16 testimony.

17 THE WITNESS: Well, my
18 understanding is -- is the purpose of the
19 model was to reconstruct or to estimate
20 how concentrations of these contaminants
21 varied in time and space.

22 BY MR. ANWAR:

23 Q. For the epidemiology --
24 epidemiological studies; right?

1 MR. DEAN: Object to the form
2 of the question.

3 THE WITNESS: Well, I think
4 that's stated here that that's the
5 ultimate goal, but, again, the model
6 itself doesn't know or care what the
7 purpose of the use of the output would
8 be.

9 BY MR. ANWAR:

10 Q. And, again, if we turn to page A182.

11 A. What page?

12 Q. A182.

13 MR. DEAN: A182? It only goes
14 to A164.

15 MR. ANWAR: Oh, I'm sorry. I
16 must have put the wrong one there.
17 Sorry.

18 BY MR. ANWAR:

19 Q. Okay. We can skip that. That's
20 fine.

21 And earlier you talked about the
22 conception or earlier we discussed the sentence in
23 your book about the importance of the conceptual
24 model, forming the conceptual model in relation to

1 efficiency and accuracy of the model.

2 Do you recall that?

3 A. I do.

4 Q. Okay. And the conceptual model, to
5 be clear, for both of the ATSDR models, Tarawa
6 Terrace and Hadnot Point, was to estimate monthly
7 contaminant concentration levels for EPI studies?

8 MR. DEAN: Object to the form
9 of the question.

10 Last time. I'm going -- next
11 time I'm going to instruct him not to
12 answer your question because you've asked
13 it now, according to my calculations, at
14 least 110 times, and his first answer is
15 all that you needed.

16 So if you don't like his
17 answer, move on to some different
18 subject, but this is the last time. I'm
19 going to let him answer it, but next time
20 I'm going to ask him to instruct him not
21 to continue answering your questions.

22 BY MR. ANWAR:

23 Q. The answer is correct; right?

24 MR. DEAN: Object to the form.

1 THE WITNESS: Can you repeat
2 the question?

3 MR. ANWAR: Okay. And your --
4 Kevin, I'm going to say, your objection
5 is noted. You know as well as I do the
6 rules with issues to objections to form
7 in a non-suggestive manner. I'm going to
8 ask you to limit your speaking
9 objections. You keep making speaking --

10 MR. DEAN: Well, we can call
11 the court because I can have this court
12 reporter read me how many times you've
13 asked that same question, and we can get
14 the judge on the phone and ask him how
15 many times you get to ask him that
16 question. It's the same one.

17 MR. ANWAR: During -- during
18 the next break --

19 MR. DEAN: Do you dispute
20 you've asked him the same question more
21 than 10 times?

22 MR. ANWAR: During the break,
23 I'm happy to do that. Let me focus on my
24 questioning.

1 BY MR. ANWAR:

2 Q. The question is the conceptual
3 model -- you would agree the conceptual model,
4 as -- as confirmed by the statements we've just
5 read from the -- from the actual reports, the
6 conceptual model for ATSDR's Tarawa Terrace model
7 and Hadnot Point model was to estimate contaminant
8 concentration levels for EPI studies; right?

9 MR. DEAN: Object to the form
10 of the question.

11 THE WITNESS: No.

12 BY MR. ANWAR:

13 Q. What was -- what was the conceptual
14 model then?

15 A. The conceptual model is your idea of
16 how the system works, how the flow system works.
17 Your understanding of what constitutes an aquifer
18 versus a confining layer.

19 The conceptual model is relevant to
20 how you structure the model. It's not -- it's not
21 a description of the purpose of the model.

22 Q. Okay. And that's -- that's a -- I
23 appreciate that clarification.

24 The conceptual model that was

1 developed for the purpose of the ATSDR Tarawa
2 Terrace and Hadnot Point/Holcomb Boulevard models
3 was developed in mind of the actual purpose for
4 which the model was being used, which was exposure
5 estimates for EPI study; correct?

6 MR. DEAN: Object to the form
7 of the question.

8 I'm not sure if anybody would
9 understand that question.

10 THE WITNESS: I don't know
11 what was in their mind when they
12 developed the conceptual model.

13 BY MR. ANWAR:

14 Q. Okay. Now, in your report, you give
15 a couple examples of other instances where --
16 well, let me back up for a second.

17 As it relates to the Hadnot
18 Point/Holcomb Boulevard model, can you point me to
19 any statement in the ATSDR reports stating that
20 that model was intended to be used for exposure
21 determinations in individuals in the real world?

22 MR. DEAN: Object to the form.

23 THE WITNESS: I would have to
24 reread the whole report carefully and see

1 if it says that. I...

2 BY MR. ANWAR:

3 Q. Having read the reports in
4 preparation for your deposition, as you sit here
5 today, can you -- can you -- are you aware of any
6 such statement in the reports?

7 MR. DEAN: Object to the form.

8 THE WITNESS: Well, I believe
9 that the Foreword that we just went over
10 describes that the ultimate purpose is to
11 evaluate the potential for health effects
12 from exposure to volatile organic
13 compounds.

14 BY MR. ANWAR:

15 Q. Okay. Can you point me to anywhere
16 in the -- in the Hadnot Point/Holcomb Boulevard
17 reports that states that particular model was
18 intended to be used in litigation as part of a
19 causation analysis for individual plaintiffs?

20 MR. DEAN: Object to the
21 form --

22 THE WITNESS: I --

23 MR. DEAN: -- of the question.

24 THE WITNESS: I don't recall

1 seeing anywhere in the reports that
2 litigation was mentioned. So I would
3 have to say no.

4 BY MR. ANWAR:

5 Q. Okay. Now, in your rebuttal report,
6 you identified two examples of hindcasting models;
7 correct? Other examples of hindcasting models;
8 correct?

9 A. I think I identified two models
10 where that had been done but had never been called
11 hindcasting.

12 Q. Okay.

13 A. And that wasn't -- that was just
14 done as part of the modeling exercise, as part of
15 the model output. It just wasn't the main purpose
16 of those models, and it was just a consequence of
17 the modeling, but in effect that's what was done.

18 Q. And that was the Rocky Mountain
19 Arsenal in Colorado example; correct? One of
20 them?

21 A. One of two examples was from the
22 Rocky Mountain Arsenal, which I'm very familiar
23 with because I had done the modeling and I had
24 written the reports about it.

1 Q. And the other one is the Lawrence
2 Livermore National Laboratory example; correct?

3 A. Correct.

4 Q. Now, the Rocky Mountain Arsenal
5 examples wasn't about reconstruction --
6 reconstructing contaminant concentrations to
7 determine exposures in individuals; right?

8 A. The issue of determining exposures
9 has nothing to do with the model, in the sense
10 that you're trying to develop a model that
11 simulates the system based on your understanding
12 of the physical and chemical --

13 THE VIDEOGRAPHER: Counsel,
14 could please fix your mic. I'm not
15 picking up your questioning.

16 BY MR. ANWAR:

17 Q. Earlier you mentioned that you had
18 been deposed related to the Rocky Mountain --

19 A. Yeah, I'm not sure I finished
20 answering the previous question --

21 Q. Okay.

22 A. -- because of the interruption.

23 But I think what I was going to add
24 was that the assessment of health effects is

1 external to the development of the model. It's
2 not in the groundwater flow and transport models.
3 It has no impact on the groundwater flow and
4 transport model.

5 You're doing the best you can to
6 develop the models that simulates -- reproduces
7 the historical distributions, but that model
8 development should not be influenced by what the
9 output might be used for.

10 MR. ANWAR: Okay. I am
11 handing you what is being marked as
12 Exhibit 10.

13 (Document marked for
14 identification as Konikow Exhibit 10.)
15 BY MR. ANWAR:

16 Q. Now, this is the article that you
17 wrote about the Rocky Mountain Arsenal study;
18 correct?

19 A. Yes.

20 Q. Okay. And in the Rocky Mountain
21 Arsenal study -- and actually if you want to look
22 at your report for this, it's on page -- it's on
23 page 3 of your rebuttal report if you want to jump
24 back to -- to that.

1 A. This? Okay. Wait. The rebuttal
2 report? Page 3? Okay.

3 Q. You state at the start of the second
4 full paragraph:

5 Hindcasting was accomplished as a
6 part of a study at the Rocky Mountain Arsenal.
7 Contamination problem in which I developed and
8 calibrated the groundwater flow and transport
9 model. The Rocky Mountain Arsenal began
10 operations in or about 1943. Groundwater
11 contamination problem was recognized in 1954 and
12 1955. "

13 Did I read that correctly?

14 A. Yes.

15 Q. Okay. And so to the extent that you
16 are estimating contaminant concentrations or
17 anything in the past, it was over that 12- or
18 13-year period from -- date from 1954, 1955 back
19 to 1943; right?

20 A. Yeah. Well, that was the first
21 period there was no data. There were several
22 other periods for which there were no data.

23 Q. Okay. And you say there were no
24 concentration data were available for the first 13

1 years of operation; correct?

2 A. Correct.

3 Q. And in Camp Lejeune for both the
4 Hadnot Point/Holcomb Boulevard and the Tarawa --
5 Tarawa Terrace models, those models are attempting
6 to reconstruct historical contaminant
7 concentrations over a 30-year period; right?

8 A. Yes.

9 Q. Okay. From observed data in 1982,
10 contaminant concentration level in 1982 till 1953
11 or earlier; correct?

12 A. Correct.

13 Q. Okay. So if we turn to the
14 Introduction, if we turn back to Exhibit 10, which
15 is your article on Rocky Mountain Arsenal, on
16 page 1, there's -- on page numerical 1, there's an
17 Introduction there; right?

18 A. Correct.

19 Q. Okay. And it says:

20 "The contamination of a ground-water
21 resource is a serious problem that can have
22 long-term economic and physical consequences that
23 might not be easily remedied. Although the
24 prevention of ground-water contamination provides

1 the most satisfactory result, the capability to
2 predict the movement of dissolved chemicals in
3 flowing ground water is also needed in order to
4 (1) plan and design projects to minimize
5 ground-water contamination."

6 Did I read that correctly?

7 A. Yes.

8 Q. So that -- that was one of the uses
9 for the model; correct?

10 A. That's potential use of models.

11 Q. Okay.

12 A. I don't believe I was talking
13 specifically about this model, but I was talking
14 about models in general.

15 Q. Okay. Number 2. "Estimate spatial
16 and temporal variations of chemical
17 concentrations."

18 Correct?

19 A. Yes.

20 Q. Number 3. "Estimate the traveltime
21 of a contaminant from its source to a ground-water
22 sink (a discharge point, such as a stream, spring,
23 or well.)"

24 Correct?

1 A. Yes.

2 Q. Number 4. "Help design an effective
3 and efficient monitoring system."

4 Correct?

5 A. Yes.

6 Q. And then number 5 is "Help physical
7 and economic feasibility of alternative
8 reclamation plans for removing contaminants from
9 an aquifer."

10 A. "Help evaluate."

11 Q. "Help evaluate." Thank you.

12 "Help evaluate physical and economic
13 feasibility of alternative reclamation plans for
14 removing contaminants from an aquifer and (or)
15 preventing the contaminants from spreading."

16 Right?

17 A. Right.

18 Q. And those were the purposes of this
19 model; correct?

20 A. Well, those -- those were listed as
21 general purposes for groundwater models --
22 groundwater contamination models. I don't think
23 those six bullet points -- five bullet points were
24 meant to be narrowly applied to the Rocky Mountain

1 Arsenal. It was more of a general introduction,
2 but yeah, that certainly would apply to the Rocky
3 Mountain Arsenal model.

4 Q. If you turn to page 40 of the model.

5 A. 40?

6 Q. Excuse me. 40 of the exhibit of
7 your study.

8 THE VIDEOGRAPHER: Sir, please
9 try and be professional. It's making
10 very muddy record.

11 MR. ANWAR: Okay.

12 BY MR. ANWAR:

13 Q. And so 40 there's a Summary and
14 Conclusions; correct?

15 A. Yes.

16 Q. The Summary and Conclusions, if you
17 go down to the third full paragraph.

18 A. Which paragraph?

19 Q. Third full paragraph.

20 A. Okay.

21 Q. "The predictive accuracy of the
22 model is most limited by adequacy of the input
23 data."

24 Did I read that correctly?

1 A. You did.

2 Q. And do you agree with that
3 statement?

4 You wrote it.

5 A. Yeah, I think I do. Yeah. Yeah.

6 Q. Okay.

7 A. Yeah, I wrote it 50 years ago. So
8 I'm just making sure I still agree with it.

9 Q. Those are the questions I have about
10 that exhibit.

11 A. Okay.

12 Q. And so the other example you gave
13 was for the Lawrence Livermore National Laboratory
14 site; is that right?

15 A. Yes.

16 Q. And I think in the -- in your
17 rebuttal report, you reference it as a study in
18 groundwater authored by Rogers; is that right?

19 A. That was Rogers, who's with the
20 Lawrence Livermore National Laboratory, or at
21 least he was when he wrote the article.

22 MR. ANWAR: Okay. I'm going
23 to go ahead and mark this as Exhibit 11.

24 (Document marked for

1 identification as Konikow Exhibit 11.)

2 BY MR. ANWAR:

3 Q. Is this the article by Rogers that
4 you were referring to --

5 A. Yes.

6 Q. -- in your report?

7 A. Yes.

8 Q. And in the Abstract there, it states
9 that:

10 "Failure to incorporate retardation
11 factors in solute transport predictions can lead
12 to serious miscalculations of the degree of
13 contamination and the time required for
14 remediation."

15 Did I read that correctly?

16 A. Yes.

17 Q. And do you still -- do you agree
18 with that?

19 A. Well, yeah, I mean, retardation
20 factors would certainly be considered if a
21 particular constituent is being retarded by
22 chemical reactions or biological reactions of any
23 kind.

24 Q. And under Introduction, it says:

1 "A ground-water model can only
2 be -- can be only as accurate as useful -- and
3 useful as the degree to which the modeled flow and
4 transport mechanisms completely represent the
5 significant characteristics of the system."

6 Do you agree with that?

7 A. Yeah, in general. Sure. Yeah.

8 Q. Now, the modeling for the Lawrence
9 Livermore National Laboratory site in California,
10 it wasn't attempting to estimate historical
11 contaminant concentrations for exposure
12 determinations in individuals; right?

13 A. Well, for one thing, the purpose of
14 the model and what it's used for has nothing to do
15 with how well the model is calibrated. That's
16 something that comes after the model. So to me
17 that just seems irrelevant to assessing the model.

18 Q. But the purpose of this Lawrence
19 Livermore National Laboratory site model wasn't to
20 attempt historical contaminant concentration
21 exposure levels in individuals; right?

22 A. The model -- the purpose of the
23 model was to reproduce what was going on in the
24 system. So.

1 Q. And what was being -- what was
2 -- what was --

3 A. So as a natural consequence, this
4 was a problem that had many analogies to Hadnot
5 Point/Holcomb Boulevard. The contamination based
6 on the historical understanding is believed to
7 have started in the early 1940s, 1942 or '43, and
8 a contamination problem was recognized decades
9 later. And the first time for which there is any
10 measurements of concentrations was around 1982 to
11 '85. So I don't remember the exact year.

12 Q. The --

13 A. So to run the model to analyze what
14 was there now -- we're in 1992 when it was done --
15 they had to start from that initial condition, a
16 period of -- I don't know what -- 30 years when
17 there was no data available and then calibrate to
18 the later data. But part of that is your -- the
19 model is in effect historically reconstructing the
20 distribution during that time in which it.

21 So in principle, it's very similar
22 to what was done in Tarawa Terrace.

23 Q. But the information that this model
24 produced wasn't used for exposure estimates --

1 A. I don't --

2 Q. -- in individuals?

3 MR. DEAN: Object to the form
4 of the question.

5 THE WITNESS: I have no idea
6 what it was used for.

7 BY MR. ANWAR:

8 Q. Can you point to -- can you direct
9 me to anywhere in the -- the article where the
10 purpose is identified as estimating concentration
11 levels for exposure determinations in individuals?

12 MR. DEAN: Object to the form.

13 THE WITNESS: I don't think
14 so.

15 MR. ANWAR: Okay. You can set
16 that aside.

17 We've been going for a little
18 while. Now might be a good time to take
19 a lunch break.

20 MR. DEAN: How long you want
21 to take? 30 minutes?

22 MR. ANWAR: What do you guys
23 think? 30? 45?

24 MS. SILVERSTEIN: I think 45.

1 MR. ANWAR: Okay. Yep.

2 MR. DEAN: See you back 1:30.

3 MR. ANWAR: Sounds good.

4 THE COURT REPORTER: We are

5 going off the record. The time is 12:46

6 PM.

7 (Whereupon, at 12:46 p.m., a
8 luncheon recess was taken.)

9

10

11

12

13

14

15

16

17

18

19

20

21

22

23

24

1 AFTERNOON SESSION

2 (1:43 p.m.)

3 LEONARD KONIKOW, PHD

4 called for continued examination and, having been
5 previously duly sworn, was examined and testified
6 further as follows:

7 EXAMINATION (CONTINUED).

8 THE VIDEOGRAPHER: We're back
9 on the record. The time is 1:43 PM.

10 BY MR. ANWAR:

11 Q. Good afternoon, Dr. Konikow.

12 A. Good afternoon.

13 Q. Hope you had a good lunch. We are
14 back on the record from a lunch break.

15 Are you okay to continue?

16 A. Yes.

17 Q. Okay. During your lunch break, did
18 you discuss the substance of your testimony with
19 your lawyers at all?

20 A. No.

21 Q. Okay. When we left off prior to the
22 lunch break, I had asked you some questions about
23 the Rocky Mountain Arsenal study that you had
24 worked on.

1 Do you recall that?

2 A. Yes.

3 Q. I wanted to ask you. You mentioned
4 that you sat for a deposition related to that
5 work.

6 Do you recall what year that
7 deposition took place?

8 A. No, I don't. It -- I looked to see
9 if I had any records of it, and I couldn't find
10 any. It was probably in the early to mid-'80s.
11 It could have been earlier. It could have been a
12 little later. I don't. I know where it was, but
13 I don't know even what year it was.

14 Q. Where did the deposition take place?

15 A. It was in the Sheraton Hotel in
16 Reston.

17 Q. Oh, in Reston out here.

18 A. Yeah.

19 Q. Okay. Thank you.

20 I wanted to ask you about some of
21 the opinions in your report.

22 So if you want to direct your
23 attention back to Exhibit 2, which is your
24 rebuttal report, and I wanted to start by focusing

1 on page 6 of your rebuttal report, which is
2 Opinion 1.

3 A. Okay.

4 Q. And there, you know, I don't want to
5 read the whole thing, but there -- there you offer
6 some opinions about in response to
7 Dr. Spiliotopoulos, and it concludes by saying, in
8 the third paragraph you say:

9 "Dr. Spiliotopoulos overstates the
10 lack of data for the Camp Lejeune groundwater
11 system."

12 Is it your opinion that
13 Dr. Spiliotopoulos overstated the lack of
14 historical concentration data available for
15 ATSDR's water modeling efforts related to Camp
16 Lejeune?

17 A. Well, that doesn't say concentration
18 data. It says he overstates the lack of data. So
19 I take that mean to all data related to the model
20 including hydraulic data, water data, and he's
21 implying or stating that there is a lack of data.

22 Q. Is it your opinion that there was a
23 lack of historical concentration data available
24 for ATSDR's modeling efforts at Camp Lejeune or

1 related to Camp Lejeune?

2 A. Well, as far as I know, it's factual
3 that there was no data between 19 -- are we
4 talking Tarawa Terrace or the other one or all of
5 them?

6 Q. For concentration -- observed data
7 for concentration levels, let's start with Tarawa
8 Terrace and then Holcomb Boulevard?

9 A. Prior to 19 -- yes, there were no --
10 best of my knowledge, there were no concentration
11 data available prior to 1982.

12 Q. Okay. And you'd agree that the
13 concentration level data for any of the VOCs at
14 issue at Camp Lejeune -- TCE, PCE, vinyl chloride
15 benzene -- prior to 1982 does not exist in terms
16 of real-world data; correct?

17 MR. DEAN: Objection.

18 THE WITNESS: In terms of
19 what?

20 BY MR. ANWAR:

21 Q. So you'd agree that prior to 1982,
22 concentration level data for any of the VOCs at
23 issue at Camp Lejeune -- TCE, PCE, vinyl chloride,
24 benzene -- it doesn't exist?

1 MR. DEAN: Object to the form
2 of the question.

3 THE WITNESS: Well, my answer
4 would be, I don't know for sure that it
5 doesn't exist, but I have not seen any
6 and I saw no reference to any.

7 MR. ANWAR: Okay. I'm going
8 to mark an exhibit.

9 Mark this as Exhibit 12.

10 (Document marked for
11 identification as Konikow Exhibit 12.)

12 BY MR. ANWAR:

13 Q. This is -- so this is Volume II of
14 the transcript from the 2005 ATSDR expert panel.

15 Would you agree with that?

16 A. Yes.

17 Q. Okay. And on the front of
18 the -- the front of the transcript, it states that
19 the meeting review -- meeting peer review panel
20 was held at Century Boulevard in Atlanta, Georgia
21 on Tuesday, March 29, 2005.

22 Do you see that?

23 A. Yes.

24 Q. Okay. And is that consistent with

1 your understanding about when the peer --

2 A. Well, I don't remember the address,
3 but, you know, that seems to be when the meeting
4 was held.

5 Q. Okay. And you don't have any reason
6 to disagree with that; right?

7 A. No.

8 Q. Okay. Now, when you -- when you
9 participated in both the 2005 and the 2009 expert
10 peer review panels, were you aware that the
11 conversations were being transcribed?

12 A. I probably was.

13 Q. Were you aware that these
14 transcripts now exist?

15 A. Yes.

16 Q. And is it fair to assume that
17 whatever discussion that took place both in
18 2000 -- at the 2005 expert panel and the 2009
19 expert panel, those were your -- your honest
20 thoughts at that time?

21 A. I would think so.

22 Q. Okay. You wouldn't have any reason
23 to attend an expert peer review panel and lie or
24 make anything up; right?

1 A. Absolutely not.

2 Q. Okay. So I wanted to have you turn
3 to page 47, and then at the bottom of 47 line 25
4 it starts by saying -- and then it will go on to
5 page 48:

6 "DR. KONIKOW: Well, you have very
7 limited data against which to calibrate your
8 model. Okay. And you know, in the period that
9 you were collecting data, the wells were
10 contaminated. Okay. So if you're going to run
11 the groundwater model, it's a question of how do
12 you get from zero to that level of concentration
13 that you're calibrating. You start with an
14 initial condition of no PCE in 1954. Okay."

15 Did I read that paragraph correctly?

16 A. You read it correctly, yeah.

17 Q. Okay. And when you said, "Well, you
18 have very limited data against which to calibrate
19 your model," those -- those were your words;
20 correct?

21 A. Apparently.

22 Q. Okay. And do you have any reason to
23 disagree with those -- those words?

24 MR. DEAN: Object to the form

1 of the question.

2 And you're also providing
3 him -- not providing the context in which
4 the -- his comments are for the several
5 pages before that.

6 BY MR. ANWAR:

7 Q. Do you have any reason to disagree
8 with what you said?

9 A. (Reviews document.)

10 Well, yeah, they were talking about
11 the calibration. No, I don't disagree with it.

12 Q. And it says "You start with an
13 initial condition of no PCE in 1954" --

14 A. Yeah, that --

15 Q. -- we're talking about Tarawa
16 Terrace; right?

17 A. Yeah. Maybe that should have been
18 '53. I don't remember the time.

19 Q. And then the next paragraph you
20 state:

21 "And then you start your model
22 running. And there's going to be speculation upon
23 assumption built into that, and you'll get a range
24 of responses. My hypothesis or my guess would be

1 that all roads will lead to contamination by 1968.
2 You may want to do the modeling to demonstrate it.
3 Maybe I'm wrong."

4 Did I read that correctly?

5 A. You read it correctly.

6 Q. And you said "there's going to be
7 speculation upon assumption built into that";
8 right?

9 A. That's what it says.

10 Q. What did you mean by "speculation
11 upon assumption built into that"?

12 A. Well, I assume that I was talking
13 about the boundary conditions and other
14 assumptions built into the model. In other words,
15 get the model run, it has to have specific numbers
16 for where fluid comes into the system, where it
17 leaves the system, where solute mass is added to
18 the system and so on.

19 And for the period where there was,
20 you know, no record, you know, that those
21 estimates have to be reconstructed from the best
22 data available.

23 So for recharge to the aquifer, you
24 look at precipitation records and maybe the

1 estimates of soil properties that you could, and
2 you make a reasonable estimate of recharge but,
3 you know, it's not an observation.

4 And, you know, the same with the
5 mass loading. You know, for Tarawa Terrace, they
6 knew where the source was, but, you know, there
7 was no one recording the people dumping the PCE.
8 So you had to make an assumption or approximation
9 about an average rate, and even with an average
10 rate, you don't know the specific rates.

11 It may have been higher one week and
12 lower the next week, and there's no way to get
13 that variability. So you would do your best to
14 estimate long-term average rates.

15 Q. Got it.

16 And in that second paragraph, you go
17 on to state:

18 "My hypothesis or my guess would be
19 that all roads will lead to contamination by
20 1968."

21 Right?

22 A. That's what it says, yes.

23 Q. Okay. And when you said 1968,
24 you're referring to 1968 as the start of the

1 epidemiological study that ATSDR was wanting to
2 perform; right?

3 A. I presume so. Again, this was 20
4 years ago. I don't remember exactly what my
5 thoughts were.

6 Q. And you go on in the third paragraph
7 to say:

8 "But you want -- the only possible
9 outcome that would differ would be a later
10 arrival, and that may be the first few years
11 there's no exposure. I think that's unlikely, but
12 that's what you want to evaluate, and that's
13 probably best -- the best you could hope from --
14 from all of these models."

15 Did I read that correctly?

16 A. You read it correctly.

17 Q. Okay. When I -- when I read this
18 section of the transcript, it -- it appears to me
19 that the question that you're addressing is
20 whether -- in terms of mass loading whether PCE
21 would have contaminated the aquifers by the start
22 of the EPI study.

23 Is that -- is my understanding
24 correct?

1 A. Well, that's my under --

2 MR. DEAN: Object to form.

3 THE WITNESS: I'm sorry. Did
4 you?

5 MR. DEAN: I just --
6 objection.

7 THE WITNESS: Okay. My, you
8 know, understanding at the time and from
9 the preliminary documents I read this, I
10 thought as a reviewer my obligation was
11 to question pretty much everything about
12 the groundwater flow and transport
13 models.

14 I don't think I really thought
15 that there would be an arrival later than
16 1968. I was just giving them a probing
17 question.

18 BY MR. ANWAR:

19 Q. Okay. Do you know for a fact --
20 well, let me -- let me back up.

21 When you say in the third paragraph,
22 "the only possible outcome that would differ would
23 be a later arrival, and that may be the first few
24 years there's no exposure," you're acknowledging

1 there the possibility that the PCE -- that Tarawa
2 Terrace was not contaminated on day one in 1953;
3 right?

4 A. On day one?

5 Q. Yeah.

6 A. I don't know that that's
7 acknowledging it, but I think it -- the first day
8 it's probably not contaminated. It takes time.
9 If they're dumping this in a drain or on the land
10 surface, it takes time to get down to the aquifer.

11 Q. Contaminants, you know, if you're
12 pumping PCE onto a land surface, it doesn't
13 immediately go into the aquifer; correct?

14 A. Correct.

15 Q. It needs to travel through the
16 subsurface; correct?

17 A. Through the unsaturated zone.

18 Q. Okay. Of the subsurface; correct?

19 A. Yes.

20 Q. Do you have any understanding of
21 how -- how long it takes for PCE to travel
22 generally or -- let's start generally.

23 A. You know --

24 MS. BAUGHMAN: Objection.

1 THE WITNESS: -- it's hard to
2 generalize, but it depends on the
3 individual circumstances.

4 BY MR. ANWAR:

5 Q. Was -- did any discussion take place
6 in the context of Camp Lejeune at the expert peer
7 panel -- peer review panel about how long it would
8 take PCE to travel from the ground through --
9 through the subsurface into the aquifer?

10 A. I don't recollect that, but I would
11 expect that the issue was mentioned and discussed
12 somewhere. But I don't recall it.

13 Q. And in your -- in the transcript
14 here, you're saying it could be a few years later
15 after ABC Cleaners started operating; right?

16 A. No, I don't think that's the case.

17 Whatever is said there, I thought
18 that was an extremely unlikely but, theoretically
19 possible, outcome. But, no, I thought from the
20 time they started dumping it, you're talking about
21 days to weeks before it reaches the water table,
22 at most a month or two.

23 I mean, because you're talking about
24 disposable of a dense nonaqueous base liquid.

1 That substance is going to sink pretty fairly --
2 pretty quickly towards the water table. Some of
3 it getting dissolved on the way down and, you
4 know, we're talking mostly about how it's moving
5 in solution, not as a dense separate phase.

6 Q. Okay. We'll return to mass loading.

7 If you could turn to -- I think your
8 might already there, but I'm looking at page 49
9 line 14 through 19.

10 And it starts "DR. KONIKOW."

11 Q. Are you with me?

12 A. Yes.

13 Q. Okay.

14 "DR. KONIKOW: But I'm guessing the
15 outcome is still going to be, from the start of
16 your epidemiological study to the end, Tarawa
17 Terrace residents were exposed, which, if you
18 could support that, it kind of mediates the need
19 for more refined modeling because it's not going
20 to yield anything more."

21 Did I read that correctly?

22 A. You read it correctly.

23 Q. And here in -- in the 2005 expert
24 peer review panel, the focus of the discussion

1 appears to be what you need for the -- the type of
2 information you need for the ATSDR epidemiology
3 -- epidemiological study that was -- was going to
4 be performed; right?

5 A. Well, I think the focus was on the
6 development of the transport model to compute the
7 concentrations needed for that, but I think the
8 focus of the modeling of our discussions that I
9 was commenting on was not the epidemiological
10 studies or the exposure. It was on the transport
11 model. You know, there were comments about the
12 epidemiological study, but that only in the sense
13 of that that's what the results were going to be
14 used for.

15 Q. So, and if we read it again:

16 "But I'm guessing the outcome is
17 still going to be, from the start of your
18 epidemiological study to the end, Tarawa Terrace
19 residents were exposed, which, if you could
20 support that, it kind of mediates the need for
21 more refined modeling because it's going to
22 yield -- it's not going to yield anything more."

23 Those are your words --

24 A. Yes.

1 Q. -- correct?

2 A. Yes.

3 Q. And when you say, "if you could
4 support exposure at the start of the EPI study, it
5 kind of mediates the need for more refined
6 modeling because it's not going to yield anything
7 more than that," what did you mean?

8 A. I'm not sure. Looking at this, I'm
9 not sure what I meant by "more refined modeling."
10 Yeah, I'm not sure. I don't remember.

11 But -- yeah. I don't know. You
12 know, I didn't read carefully the several pages
13 before this to look for context of that comment.

14 Q. Okay. But you're not denying
15 that -- when you say -- scratch. Strike that.

16 When you say "because it's not going
17 to yield anything more than that," what did you
18 mean?

19 A. I assume that it meant it would
20 yield the concentration distributed over time and
21 from that the concentration in the water supply
22 wells and that's -- that's what you'd expect from
23 it.

24 Q. Okay.

1 A. Certainly these models were not
2 going to assess human health effects from these
3 models themselves. That's a totally other
4 different thing that has to be used. But these
5 models provide the input to that type of
6 assessment.

7 Q. I will say, aren't you saying
8 here -- so as an outside observer or someone who
9 didn't participate in this panel, what it looks
10 like you're saying here is that the best that the
11 TT model -- the Tarawa Terrace modeling can do is
12 determine whether the population at Tarawa Terrace
13 would have been exposed or not?

14 MR. DEAN: Object to the form
15 of the question.

16 THE WITNESS: No, that's not
17 what I --

18 BY MR. ANWAR:

19 Q. Because you say --

20 A. -- meant.

21 Q. -- "it's not going to yield anything
22 more than that"?

23 A. I meant the concentration at the
24 location of the water supply wells is I think what

1 I was referring to. By, you know, "more refined
2 modeling," perhaps I meant with a finer grid or a
3 finer time step or something, but, again, I don't
4 recall exactly what I meant by that term.

5 Q. Okay. So it's your testimony today
6 that you have no recollection of what your words
7 here mean?

8 A. Well, I wouldn't say that.

9 The specific term "more refined
10 modeling," I don't recall what I was thinking at
11 that point, but the general gist there I think is
12 still clear and I would agree with.

13 Q. If you were asked to describe a more
14 refined model in present day terms, how does a
15 more refined model compare to a simpler model?

16 A. Well, a more refined model could be
17 solving the same governing equations but do it
18 over a much finer grid with a much better
19 definition of hydraulic properties.

20 Hydraulic properties is something
21 you don't have to go back in time to get because
22 they remain constant in time. So you could drill
23 more wells, get more pumping tests, get a better
24 definition, maybe use a new geophysical method,

1 get a better definition of the porosity
2 distribution, and that would be a more refined
3 model with possibly smaller grid spacing and
4 better definition of hydraulic parameters.

5 A more refined model might be one
6 that includes more processes that weren't included
7 in the transport model. I'm not sure what exactly
8 that would be, but maybe instead of using a
9 retardation factor, it tried to represent the
10 actual chemical and biogeochemical processes more
11 accurately than the simplified approximation of
12 using the retardation factor.

13 So you could have a more refined
14 model in terms of the processes that affect the
15 concentration as it's being transported, but, you
16 know, the use of a retardation factor is a common,
17 standard way of simplifying all the reaction
18 terms.

19 Q. When -- when you start developing a
20 new model, do you start with a more refined model
21 or do you start with a simpler model and then
22 build towards a more refined model?

23 A. Well, we try to start as, you know,
24 after we build the conceptual model of what's

1 going on, we'll try to build as simple as possible
2 and see if we need to, you know, refine the grid
3 spacing, add more processes, anything like that.

4 So yeah, general rule is, you know,
5 you develop a conceptual model about what the
6 governing processes are, what needs to be
7 considered, and then you develop a model.

8 You discretize it at some grid
9 spacing that seems reasonable based on your
10 judgment and experience, and you assess whether or
11 not that's adequate one way or another, usually
12 through numerical experiments. And if it's not,
13 use a finer grid, and if it's adequate, you either
14 stick with it or maybe even based on computational
15 efforts you might decide to use a coarser grid to
16 reduce the computational time.

17 Q. Does the term -- and I may -- may
18 mispronounce this, but does the term "parsimony"
19 mean anything to you?

20 A. Parsimony.

21 Q. Parsimony?

22 A. Yeah. It's basically a fancy way of
23 talking about the simplicity or complexity of the
24 model. Parsimony implies you use the simplest

1 possible approach. You want a parsimonious model.

2 Q. Okay. Why is that?

3 A. Well, the more complex a model is,
4 the harder it is for the modeler and the analyst
5 to understand what the model is doing. And you
6 want to -- it's obviously better if you understand
7 what the model does. The simpler the model is,
8 the more you can understand what is going on in
9 the model mathematically.

10 If you have a multitude of reaction
11 terms and transport terms and all in the same
12 model and something unexpected happens or
13 something showing up, you're not sure exactly why
14 that's happening. There's too many things to do,
15 to look at.

16 So, you know, you always want to use
17 the simplest possible model, but the difficulty is
18 always assessing how do you know that it's not too
19 simple. And there's judgment calls in there and
20 discussions with colleagues and so back and forth.

21 It's not just a perfectly objective
22 type of assessment. You need some judgment calls
23 and decisions as to what level of complexity to
24 build in. It's not necessarily that one is wrong

1 or one is better, but sometimes there's, you know,
2 in modeling, particularly in the older days, there
3 was always a trade-off with computer resources
4 because you were much more limited 20, 30 years
5 ago in terms of computer capabilities than you are
6 today. So that always factored into it in terms
7 of efficiency versus, let's say, complexity and
8 accuracy.

9 Q. Okay. In terms of adding complexity
10 to a model, are there circumstances under which
11 adding complexity to a model could increase the
12 uncertainty or decrease the accuracy of the model?

13 A. I suppose. I mean, if you add more
14 and more processes, then you're going to require
15 more and more parameters that need to be defined.
16 And if you don't have good ways to measure those
17 parameters, then you're in effect adding more
18 uncertainty even though you're representing more
19 processes.

20 So it's not always a good thing to
21 do, and, again, it may mask what's really
22 happening in terms of what's causing things to
23 happen.

24 Q. Okay. Thank you.

1 On page 7 of your rebuttal report,
2 Exhibit 2. I'm going to be jumping --

3 A. What page?

4 Q. It's --

5 A. 7?

6 Q. I'm going to be jumping back and
7 forth between your rebuttal report and probably
8 the transcript. So it might be good to have both
9 side by side or -- or I can tell you. Let me do
10 it this way.

11 There is a reference in your report,
12 it's in Opinion 2, where you mention that
13 Dr. Spiliotopoulos -- Spiliotopoulos says that the
14 results are conservative. You said:

15 "Dr. Spiliotopoulos says this
16 results in conservative estimates of estimated
17 monthly contaminant concentrations. It is not
18 clear what is meant by 'conservative' or why that
19 is not a good trait. He also says the results are
20 biased high."

21 If you'd like to read it, it's in
22 Opinion 2 page 7.

23 But do you recall that portion of
24 your opinion?

1 A. Yeah, I'm looking at it now. Yes.

2 Q. Okay. And so if you go back to the
3 transcript that we were just looking at, the 2005
4 transcript.

5 A. Yeah.

6 Q. On page 49. You question in your
7 report:

8 "It is not clear what is meant by
9 'conservative' or why that is not a good trait."

10 And right after 14 and 19, the
11 discussion we were just having about your
12 comments, Mr. Maslia responds:

13 "Then from the standpoint of being
14 conservative from a public health standpoint,
15 let's assume we refine our groundwater
16 understanding and we get" -- and then he goes on.

17 When we're talking about -- sort of
18 as reflected in Mr. Maslia's statement there, when
19 we're talking about conservative in terms of
20 ATSDR's Camp Lejeune modeling, we're talking about
21 from a public health standpoint; right?

22 MR. DEAN: Object to form.

23 THE WITNESS: I -- I don't
24 recall what he was talking about, but he

1 says "from a public health standpoint."

2 BY MR. ANWAR:

3 Q. What does "conservative" mean to you
4 from a public health standpoint?

5 A. To me that implies being very
6 careful and safe on what you're doing and not
7 going beyond the basis of the data and supporting
8 modeling studies. You know, it could mean other
9 things.

10 Q. Would you agree that conservative
11 from a public health standpoint could mean being
12 health protective?

13 MR. DEAN: Object to the form.

14 THE WITNESS: I'm -- yeah,
15 you know, I'm not a health expert or an
16 epidemiologist. So I'm not sure what
17 common usage of that means, but that
18 sounds okay.

19 BY MR. ANWAR:

20 Q. Because, I mean, we've discussed
21 this.

22 The modeling was being used for --
23 to produce information for an EPI study; right?

24 MR. DEAN: Object to form of

1 the question.

2 THE WITNESS: Yeah.

3 MR. DEAN: You asked 122.

4 BY MR. ANWAR:

5 Q. Okay. And from a public health or
6 safety standpoint, wouldn't you err on the side of
7 making assumptions and using inputs that you
8 consider sort of results of exposure that's at
9 greater risk to the public?

10 A. I guess I think I need a more
11 specific example, but maybe repeat the question.

12 Q. So, for instance --

13 A. Yeah.

14 Q. -- we were talking about mass
15 loading a moment ago; right?

16 A. Yeah.

17 Q. And there was a question whether
18 mass loading started on -- for Tarawa Terrace
19 whether it started in 1953, the day that ABC
20 Cleaners opened; correct?

21 A. Yeah.

22 Q. Okay. And I think at least in the
23 passage that we discussed, there was a discussion
24 about whether or not the mass could have

1 traveled -- it would have taken a couple years for
2 the mass to travel through the aquifer so that --

3 A. To where?

4 Q. In Tarawa Terrace. The mass. We're
5 talking about the Tarawa Terrace model.

6 A. To travel from where to where?

7 Q. From the dumping on the ground from
8 the dry cleaner to the subsurface into the
9 aquifer.

10 A. No, we did not say.

11 I said that it would probably take
12 days to weeks, maybe a month or two. That's what
13 I would -- that I would estimate was the travel
14 time from disposal by the dry cleaners into the
15 land surface until it reaches the water table,
16 which I would think was on the order of 20 feet
17 below the land surface.

18 Q. Okay. Let's -- let's take what
19 you're saying out. We'll return to your
20 statements.

21 But let's say, for instance, the
22 question was whether you decide the concentration
23 started mass loading immediately into the aquifer
24 in 1953 or 1960.

1 And if you were deciding between
2 those two start dates, from a public health
3 standpoint, isn't it more health protective to
4 assume -- to assume more people were exposed than
5 less to protect those people?

6 MR. DEAN: Object to form.

7 THE WITNESS: I'm not
8 qualified to answer that.

9 But what I will say, from the
10 perspective of the model, being
11 protective of public health really should
12 not enter into your assessment of mass
13 loading, hydraulic properties, or
14 anything else related to the model should
15 not be influenced by any perception of
16 health effects. That would not be sound
17 application of groundwater modeling.

18 BY MR. ANWAR:

19 Q. And are you saying that -- well, why
20 not?

21 A. The development of a groundwater
22 model should be based on your understanding of the
23 hydrogeologic framework of the boundary
24 conditions. Mass loading is one type of boundary

1 condition, and it should be based on
2 hydrogeological and hydrochemical evidence.

3 You know, basically I don't see why
4 you would, you know, in developing, doing your
5 best scientific engineering efforts to develop a
6 sound model, a reliable model, what you put into
7 that data set of input parameters, or input data
8 sets, should reflect your understanding of the
9 aquifer system and the stresses on it.

10 And it should not -- that by itself
11 should not be influenced by what you think the
12 outcome might be or how you might protect human
13 health. Protection of human health is not a
14 component of groundwater modeling.

15 Q. Are you saying that ATSDR, as a
16 public health agency and performing this -- this
17 modeling related to Camp Lejeune, didn't account
18 for protecting human health?

19 MR. DEAN: Object to the form
20 of the question.

21 THE WITNESS: In my mind and
22 in my recollection of everything that was
23 described, there was an impartial
24 scientific objective assessment to get

1 the best estimates of the input
2 parameters, and I could -- I did not see
3 any evidence that the selection of
4 parameters, boundary conditions, initial
5 conditions were influenced by ATSDR's
6 health mandates.

7 BY MR. ANWAR:

8 Q. Why would a public health agency
9 perform groundwater modeling for estimating
10 contaminant concentrations without considering its
11 mission to protect public health?

12 MR. DEAN: Object to the form
13 of the question.

14 THE WITNESS: I would hope
15 that they would want to get the best
16 possible scientific estimate of how those
17 contaminants move through the ground.

18 The estimate of the truth --
19 and, again, it's clearly estimating what
20 had happened historically -- is what
21 needs to be known.

22 They don't need to know an
23 estimate that would be protective of
24 human health. They need an estimate of

1 what actually happened.

2 BY MR. ANWAR:

3 Q. Okay. Based on this conversation
4 that we've been having, are there any parameters
5 that you would consider undesirable? Let's start
6 generally.

7 A. Undesirable with respect to what?

8 Q. Well, let me strike that.

9 Are there any parameters that in
10 evaluating ATSDR's water models that you
11 determined to be undesirable?

12 A. Again, I'm not sure what you mean by
13 "an undesirable parameter."

14 I mean, there are parameters in the
15 model which basically reflect coefficients in the
16 governing equations. They're all there because
17 it's believed they're part of the governing
18 processes. So a characteristic of desirability
19 just is inappropriate and irrelevant.

20 Q. Now, I want to turn back to the
21 opinion or critique you offered of
22 Dr. Spiliotopoulos in terms of overstating the
23 lack of historical concentration data available.

24 Could you please turn to page 193 of

1 the transcript that you're looking at.

2 A. This is from the 2005? Volume II
3 from 2005?

4 Q. Correct.

5 A. Repeat the page.

6 Q. 193.

7 A. 193?

8 Q. Correct.

9 A. Okay.

10 Q. And in the middle of the page
11 starting at line 11, you're sort of concluding --
12 it's towards of the panel. You can see the
13 transcript. It's towards the end of the
14 transcript.

15 "DR. KONIKOW: Well, again, I second
16 all the comments that have been made up to now. I
17 again just reiterate what the groundwater modeling
18 and the transport modeling that ultimately we're
19 limited in what we can do in terms of the
20 available data. I mean, you know, we don't have
21 concentration data before 1980 or '82, and so
22 everything we do for looking at distribution
23 before then is going to be a little fuzzy."

24 Did I read that correctly?

1 A. Yes.

2 Q. And those are your words; right?

3 A. Yes.

4 Q. What did you mean by "and so
5 everything we're going we do" -- so -- strike
6 that.

7 What did you mean by "and so
8 everything we do for looking for at distribution
9 before then is going to be a little fuzzy"?

10 A. Talking about before 1982 or so, the
11 period in there. That the modeling -- when I say
12 a little fuzzy, but what that means is you're
13 going to make some prediction, decide, you know,
14 your best calibration, your best fit.

15 But you have to recognize that
16 there's confidence limits about that and there may
17 be a band of uncertainty and that you have to, you
18 know, assess that and consider that and, you know,
19 not take the one prediction of mean as the gospel,
20 but you have to consider -- and this is some of
21 the things that ATSDR did.

22 They present many graphs with a band
23 about their best fit calibration, and this is a
24 way to reflect -- well, I use the term "a little

1 fuzzy," which is not really a scientific term but,
2 you know, it recognizes that you have to -- that
3 there's uncertainty in the estimate. There's
4 uncertainty in the results. Your best fit model
5 gives you, you know, a precise estimate, but you
6 have to recognize that it could be above it or
7 below it.

8 Q. And --

9 A. And I think that's kind of the
10 consideration of that was followed with good
11 practices by ATSDR and presented their results
12 clearly showing, well, in that term "fuzziness"
13 but they really showed a band about the estimate
14 for different sources of uncertainty.

15 Q. And there's uncertainty in the
16 results prior to '82 because, as you say there,
17 "we don't have concentration data before 1980 or
18 '82"; right?

19 MR. DEAN: Object to the form
20 of the question. I'm not sure what the
21 question was.

22 BY MR. ANWAR:

23 Q. Correct?

24 A. We have a very, I believe, high

1 confidence at the start of the period that there
2 was initial conditions and initial concentrations
3 that were, zero and then we have no data until
4 about 1982 or so, and so that's what the model was
5 used to reconstruct how that might be.

6 And the model basically is saying
7 that there are certain processes we know govern
8 the fate and transport of dissolved constituents
9 and the movement of groundwater, and the way we
10 make our estimation or calculation of the
11 concentration there, we do it in a way that is
12 consistent with everything we know about the
13 physics.

14 Q. You just described uncertainty, and
15 I just want to confirm.

16 That uncertainty exists because
17 there isn't concentration data before 1982?

18 A. It exists for more reasons than
19 that. It exists because the uncertainty in the
20 definition of the hydraulic conductivity. There's some
21 uncertainty in porosity. There's some
22 uncertainty -- well, every parameter there's some
23 uncertainty. Nothing is known exactly.

24 The KDS and RFs, the retardation

1 factor, these are all engineering approximations
2 for the processes that in reality are much more
3 complex. They're not a true and precise
4 representation of all the processes that that
5 causes.

6 It's an engineering process
7 that -- approximation that is very common in
8 modeling and very well accepted and it's almost,
9 you know, it's there because it's a necessity. It
10 helps keep the model as simple as possible. It
11 keeps you towards parsimony, but we know it's an
12 approximation.

13 The real processes that control
14 retardation are probably nonlinear, they're not
15 instantaneous, and they vary in space and they
16 could vary in time. If you look at a retardation
17 factor or a KD for one constituent, it may
18 actually depend and vary depending on the
19 concentration of a different constituent.

20 And, you know, all these -- none of
21 those complexities are incorporated into the RF or
22 into a KD. So they're simple -- simplifying
23 approximations, and that's what we do in effect to
24 some degree or another with everything in the

1 model.

2 MR. ANWAR: Understood. Thank
3 you.

4 Give me one second. I'm going
5 to grab a document.

6 Let's go off the record for
7 one second.

8 THE VIDEOGRAPHER: We're going
9 off the record. Time is 2:28.

10 (A recess was taken.)

11 THE VIDEOGRAPHER: We're back
12 on the record. The time is 2:45 PM.

13 BY MR. ANWAR:

14 Q. We're back on the record after a
15 very short break.

16 Thank you for bearing with me,
17 Dr. Konikow.

18 I am handing you -- well, are you
19 okay to continue?

20 A. Yes.

21 Q. And did you speak about the
22 substance of your testimony with your --

23 A. No.

24 Q. Okay. With your lawyers during the

1 break?

2 A. With what?

3 Q. With your lawyers during the break?

4 A. No.

5 MR. ANWAR: Okay handing you
6 what's being marked as Exhibit 13.

7 (Document marked for
8 identification as Konikow Exhibit 13.)

9 BY MR. ANWAR:

10 Q. And sort of still on the topic of
11 Dr. Spiliotopoulos's -- well, still on the topic
12 of your criticism about Dr. Spiliotopoulos's
13 -- Spiliotopoulos's statement on the lack of
14 historical data, I've handed you the expert panel
15 summary from 2009.

16 Would you agree with that?

17 A. Yes.

18 Q. Okay. The title on the document is
19 "Expert Panel Assessing ATSDR's Methods and
20 Analyses for Historical Reconstruction of
21 Groundwater Resources and Distribution of Drinking
22 Water at Hadnot Point, Holcomb Boulevard, and
23 Vicinity, U.S. Marine Corps Base Camp Lejeune,
24 North Carolina."

1 Did I read that correctly?

2 A. Yes.

3 Q. And the date of the expert panel is
4 identified -- the 2009 panel as April 29 to 30,
5 2009; correct?

6 A. Yes.

7 Q. Okay. So I'd like you to turn to
8 page 99.

9 Page 99 is labeled "Appendix E" to
10 this, the expert panel summary that I just
11 handled -- handled -- handed you.

12 Do you see that there?

13 A. Yeah.

14 Q. Okay. And it -- I'll represent to
15 you that it appears to be comments submitted by
16 you. I'm not sure if it was before or after the
17 expert panel.

18 Do you recognize this document?

19 A. My recollection is that these were
20 questions submitted before the panel before we
21 met.

22 Q. Okay.

23 A. And the answers were prepared before
24 we met, not with all the information given at the

1 panel.

2 Q. Okay. And so I wanted to turn your
3 attention to the middle of the page -- page
4 starting "CHARGE TO PANEL" in all bold.

5 Do you see that there?

6 A. "CHARGE TO PANEL"? Yes.

7 Q. Okay. And the question is: "Do the
8 data analysis and computational methods provide an
9 adequate level of accuracy and precision?"

10 Correct?

11 A. Yes.

12 Q. Okay. And your comment there
13 states:

14 "The approach taken appears to be
15 quite reasonable, as far as can be told from the
16 available information and with exceptions noted or
17 discussed below, but indeed the level of accuracy
18 and precision may still not be adequate because of
19 the paucity of data and complexity of contaminant
20 sources during the time period when the history is
21 to be reconstructed."

22 Did I read that correctly?

23 A. Yes.

24 Q. Okay. And then you go on to say:

1 "The adequacy will depend in large
2 part on the reliability and soundness of the
3 groundwater flow and transport models that will be
4 developed (but which have not been adequately
5 described in the reviewed documents). As noted in
6 comments below, the approach used to estimate
7 reaction rates appears to lack a firm theoretical
8 basis for providing confidence in the accuracy and
9 precision of calculated values."

10 Did I read that correctly?

11 A. You read it correctly.

12 Q. Okay. And these are your words;
13 correct?

14 A. Apparently.

15 Q. And you said you submitted this
16 before -- these -- these comments before the
17 panel -- expert panel in 2009?

18 A. Before we met, yes.

19 Q. Okay. And they were specifically in
20 response to questions that were issued before you
21 met for the 2009 panel?

22 A. As I recall, before we met, they
23 sent us a short list of -- I don't remember --
24 four, five, six questions that they requested we

1 answer as best we could based on the knowledge we
2 had. And I think they had sent us some documents
3 to review ahead of time, but it was not a
4 comprehensive presentation of everything done at
5 the site.

6 Q. Do you recall what documents they
7 sent you to review ahead of time?

8 A. I do not.

9 Q. This summary report was published
10 after the expert panel had taken place, though;
11 right?

12 A. Yes.

13 Q. Okay. And your comments were
14 attached as an appendix; correct?

15 A. Apparently, yes.

16 Q. Okay. And so in that first
17 sentence, you say:

18 "But indeed the level of accuracy
19 and precision may still not be adequate because of
20 the paucity of data and complexity of contaminant
21 sources during the time period when the history is
22 to be reconstructed."

23 When you say "the level of accuracy
24 and precision may still not be adequate because of

1 the paucity of data," what do you mean by "paucity
2 of data"?

3 A. I think -- and, again, this is from
4 15 years ago. I think I was referring to the
5 source terms and the lack of observed
6 concentration values in the, you know, 30-year
7 period or so.

8 But the source term, you know, is an
9 obvious, important characteristic for the model or
10 probably for the model parameter. And it was
11 clear that for the Hadnot Point/Holcomb Boulevard
12 area, there were many more sources -- potential
13 sources of contamination than there were for the
14 previous Tarawa Terrace -- Tarawa Terrace models.

15 And I thought that added more
16 complexity and uncertainty to the -- what would be
17 the overall model results.

18 Q. Do you recall how many sources there
19 were for Hadnot Point/Holcomb Boulevard?

20 A. I thought there were tens of
21 potential sources, dozens of sources, individually
22 numerous storage tanks, industrial areas where
23 things were going on, different buildings had
24 different activities. There were just a multitude

1 of potential sources.

2 Q. The last sentence in that paragraph:
3 "As noted in comments below, the
4 approach used to estimate reaction rates appears
5 to lack a firm theoretical basis for providing
6 confidence in the accuracy and precision of the
7 calculated values."

8 What did you mean by that?

9 A. I don't recall. I assume the
10 "reaction rates" is referring to either absorption
11 reactions and/or the degradation term. I don't
12 recall what exactly I meant there.

13 Q. If you turn the page to page 100,
14 there is a second question there that starts with
15 an ellipses "reconstructing historical contaminant
16 concentrations."

17 Do you see that there?

18 A. Number 2?

19 Q. Yes.

20 A. I see it.

21 Q. Okay. And 2a there states
22 "anticipated data analysis and model modeling
23 complexities?"

24 That was the question; right?

1 A. I guess, yeah.

2 Q. And your response there:

3 "Overall, the task at hand is an
4 enormously difficult and challenging one, and
5 there are numerous difficulties confronting a
6 successful completion. There are numerous sources
7 of uncertainty both in the data analysis and the
8 modeling results. Attempts should be made
9 throughout the course of the project to quantify,
10 as well possible, the degree of uncertainty in
11 each stage of the work. In the transport
12 modeling, the issue of estimating the appropriate
13 magnitude of the dis --

14 A. Dispersivity.

15 Q. -- dispersivity -- thank you --
16 coefficients is a difficult one for which there is
17 no simple answer or standard. This will certainly
18 be clouded by the use of the finite-difference
19 solution method in the MT3D transport model, and
20 the effects of numerical dispersion on calculated
21 early arrivals and breakthroughs, as well as on
22 peak concentrations, must be carefully considered
23 and evaluated, and alternative solution methods
24 and discretizations considered."

1 Did I read that correctly?

2 A. You did.

3 Q. Can you elaborate a little bit here
4 on what you meant by "the task at hand is an
5 enormous -- enormously difficult and challenging
6 one, and there are numerous difficulties
7 confronting a successful completion"?

8 A. Well, you know, I think in any
9 groundwater model, flow model or transport model,
10 that's ever been developed, they face an
11 enormously difficult challenge in representing the
12 hydrogeologic framework in a mathematical way, as
13 well as defining all the stresses on the system
14 and so on.

15 In that sense, all the problems I
16 faced here are problems that every groundwater
17 model ever made over real system faces the same
18 challenges. The degree of data available just
19 varies.

20 I emphasize again that my answers to
21 these questions were done before we had any
22 presentation by the technical people at
23 ASTDR -- ATSDR on what they actually did.

24 We had some preliminary draft

1 documents, which I don't recall what they were,
2 but these answers that are prepared were prior to
3 receiving any feedback or any answers on the
4 questions.

5 So I had questions, but this was
6 before I got any answers, but these are all issues
7 that every modeler -- groundwater modeler always
8 faces.

9 You know, here, particularly at the
10 Hadnot Point, there was, you know, probably a more
11 complex set of source terms than in many studies,
12 not in all studies but in many problems.

13 Any specific comment you want me to
14 address in a little more detail?

15 Q. Sure.

16 Before I ask you about specific
17 comments you made, I think you stated that every
18 groundwater model faces sort of these challenge.

19 Does every groundwater model
20 estimate contaminant concentrations that are now
21 used -- that are now being attempted to be used to
22 determine exposure on individuals?

23 A. I doubt it but, you know, again,
24 that end use of the modeling results really should

1 not influence the development of the model to any
2 degree. The model -- the people who develop
3 groundwater models are going to look at the
4 hydrogeologic frame, the stressors, all the
5 parameters in the model and do the best possible
6 job they can to define the input data.

7 And the definitions of the input
8 data for the model should not be affected by what
9 they perceive as the ultimate use of the model,
10 and many descriptions of groundwater models in the
11 literature describe the groundwater model, the
12 reliability, sensitivity, all of those things, but
13 they very often do not describe what the model
14 results may have been used for by other people.

15 Q. I understand that you're saying now
16 that the -- the model results really -- and you
17 should correct me if I'm misunderstanding your
18 testimony.

19 What the model results are used for
20 are really not relevant to performing the model;
21 is that right?

22 A. They're all -- they're only relevant
23 to the extent that you want to make sure the model
24 will yield results that are relevant to the people

1 paying for the model development.

2 In other words, if you know they're
3 going to use it for health studies based on what
4 you predict in the -- the concentration history in
5 water supply wells, if that's, you know, what it
6 will be used for, then you want to, you know, kind
7 of make sure anything related to that gets special
8 emphasis in being as reliably estimated as
9 possible.

10 So it's just a very general sense
11 that that would have feedback into the model but,
12 you know, in general, the standard of practice in
13 developing a groundwater model anywhere is you
14 make your best effort at every parameter that goes
15 into it.

16 But where it might influence, well,
17 if you know this, then you might say, we have to
18 drill a couple more wells or we have to invest
19 more money and, you know, that kind of feedback
20 that you would do to do a better study.

21 But if you don't have that
22 opportunity to, you know, spend another five years
23 drilling test wells and so on, you do the best you
24 could and that's the standard. Do the best you

1 could based on your understanding and knowledge of
2 the principles, the governing equation, and the
3 mathematics.

4 Q. Okay. And the reason I was asking
5 that was because sort of going back to the section
6 Chapter 20 of your -- your book chapter, in the
7 section discussing model design development and
8 application, the first sentence of that section
9 is:

10 "The first step in model design and
11 application is to define the nature of the problem
12 and purpose of the model."

13 Isn't that right?

14 A. That's what I said. I still think
15 that's reasonable.

16 Q. So when you're designing a model,
17 isn't it unreasonable to -- to divorce how the
18 results of the model will be used from the
19 developing the actual model itself?

20 A. Well, you don't want -- you don't
21 want to divorce it in the sense of being totally
22 ignorant of what it is. Because that may
23 affect -- if you know the model will be used and
24 the results will rely on your estimates of

1 concentration in a water supply well, you're going
2 to design your grid, your spatial discretization
3 grid for the model to make sure it's fine enough
4 around those observation -- around those water
5 supply wells to feel that you will get a
6 reasonably accurate result in those water supply
7 wells.

8 Whereas, if your purpose is to look
9 at regional flow and what might get into the river
10 at the end, you wouldn't worry so much about
11 having to find enough grid around the supply
12 wells. You'd be okay instead of 50 feet okay 200
13 feet, you know, things like that.

14 So in the sense of being aware of
15 the use of it, you want to know what the
16 ultimate -- the end users need and what they're
17 going to need, and that certainly can affect how
18 you design the model.

19 It should not influence your
20 selection of parameter values. It should not
21 influence your selection of boundary, but it might
22 influence your grid space and your time step. You
23 know, if -- if the end user only is interested in
24 how things change on a yearly basis, well, then

1 you use annual time steps. If they're interested
2 in a monthly basis, you might use monthly time
3 steps. So in that sense, it affects how you
4 design the model.

5 Q. Understood.

6 So turning to -- back to the 2009
7 expert summary comments, your comments, 2b there
8 says:

9 "Which modeling methods do panel
10 members recommended ATSDR use for reliable monthly
11 mean concentration results for exposure
12 calculations?"

13 Your comments are:

14 "The proposed modeling methods
15 appear to be quite reasonable and appropriate to
16 the task, although given the complexity and the
17 uncertainty in the underlying database, there is
18 no guarantee about the accuracy and reliability of
19 the results; those will need to be assessed as the
20 work progresses. Within the broad framework of
21 using MODFLOW and MT3D, details of the approach
22 and implementation must be carefully evaluated,
23 and alternatives considered, to assure the maximum
24 chance of achieving reliable results."

1 Did I read that correctly?

2 A. You did.

3 Q. Okay. And what did you mean there
4 by, although in the first sentence, "The proposed
5 method -- the proposed modeling methods appear to
6 be quite reasonable and appropriate to the task,"
7 and then you go on, "although given the complexity
8 and uncertainty in the underlying database, there
9 is no guarantee about the accuracy and reliability
10 of the results"?

11 What did you mean by "the complexity
12 and the uncertainty in the underlying database"?

13 A. Well, I mean, I think we've said
14 this several times already that there's a period
15 in which there were no observations of
16 concentration over a period of a number of years
17 until the early '80s.

18 The hydrogeologic framework
19 everywhere always has uncertainty in it for every
20 case, not just Camp Lejeune.

21 There's multiple sources, you know,
22 it's a complex subsurface environment. For the
23 Hadnot Point, you had very complex source terms,
24 at least in the sense that they were in many

1 areas, and there were no direct observations that
2 I recall of what leaked when. They had to make
3 assumptions.

4 And I was just, you know, again,
5 this is before we had the presentations, and I was
6 cautioning, you know, be careful, be as accurate
7 as possible, evaluate the uncertainty and, you
8 know, consider alternative approaches and
9 alternative considerations.

10 It was just these are just, you
11 know, good general warnings and guidelines for any
12 important modeling project, and, you know, this
13 was before I heard what they did or saw their end
14 results.

15 Q. Okay. So is it your testimony that
16 your -- so we've looked at a number of statements
17 from the 2005 transcript, as well as now the 2009
18 expert panel summary document where you raised --
19 you pointed to the lack of historical data and
20 questioned -- raised questions about uncertainty
21 and whether accuracy could be obtained.

22 And you've noted that this was
23 before you actually sat through the 2009 expert
24 panel.

1 Do you no longer hold the concerns
2 that are reflected in all, you know, in your own
3 words in the transcripts and in the summary
4 documents?

5 A. Some of my concerns -- all my
6 concerns, I mean, these, all the issues that were
7 brought up were responded to. I had concerns
8 about numerical dispersion because in the MT3D
9 model they used a central finite-difference scheme
10 to solve the governing equations.

11 The reason for doing this is that
12 that's much more numerically efficient computer.
13 The simulations will take less real time with the
14 finite-difference method than with the TVD method,
15 and so I cautioned them to assess alternatives and
16 be aware of the numerical dispersion as a
17 possibility.

18 And I saw in the later reports that
19 they followed up on that, and they did testing and
20 they compared it with a method of characteristics
21 model and with a TVD model. And these refer to
22 just the specific numerical methods used to solve
23 the solute transport equation. That's a governing
24 equation. There's nothing different in the

1 equation.

2 So just alternative numerical
3 methods that were available at that time, and
4 they -- they, I guess, took my advice and they
5 made assessments. And I looked at the results,
6 you know, later on or recently reviewing the
7 documents, and I was very impressed at how little
8 difference it made.

9 Everything I saw. So. Oh, sorry.
10 Okay. I was drifting off the record.

11 Q. Okay.

12 A. Everything I saw showed that there
13 was negligible effect of the solution method,
14 indicating that numerical dispersion was not a
15 problem.

16 Q. When you say after sitting through
17 the expert panel and when you looked at the final
18 product again that they addressed your concerns.

19 When did you look at the final
20 reports again?

21 A. The final reports were -- I don't
22 know -- sometime after 2013, whenever they were
23 published, but I, you know, I looked at them again
24 in the last month or two. I don't remember

1 exactly when I first saw the final products.

2 Q. So you looked at -- you looked at
3 the reports again after you had been retained as a
4 litigation expert; correct?

5 MR. DEAN: Objection to the
6 form.

7 THE WITNESS: You mean
8 recently I've --

9 BY MR. ANWAR:

10 Q. Correct.

11 A. Yes, I -- I looked at every one of
12 the reports for both Tarawa Terrace and Hadnot
13 Point. I read -- reread some of them in more
14 detail and more slowly and some of them in less
15 detail less slowly, but I did go every one of
16 them.

17 Q. Is there any document or anything
18 that you can point to reflecting that your
19 concerns that you raised at the expert panels and
20 that's reflected in the summary -- the summary
21 report, is there any document you can point to
22 prior to your retention as an expert reflecting
23 that the concerns had been addressed?

24 A. Yeah. I think the content is in the

1 reports, that they did tests for grid spacing to
2 look at the possible effects of oscillations and
3 numerical dispersion in the solution. They -- I
4 don't remember which report it's in, but I did
5 -- I do recall seeing it that they tested it and,
6 you know, there was not a problem there in terms
7 of any substantive effect on the accuracy of the
8 solution with the method that they did use. And
9 I'm talking about the numerical accuracy of the
10 solution.

11 Q. I guess what I'm asking --

12 MS. BAUGHMAN: Wait. Were you
13 finished?

14 THE WITNESS: I was going to
15 say a little more but, you know, --

16 MR. DEAN: Go ahead.

17 THE WITNESS: -- I was
18 essentially finished.

19 BY MR. ANWAR:

20 Q. Go ahead if you'd like to say
21 anything more.

22 A. Well, and I can't remember, again,
23 where it was but, you know, the whole issue of
24 numerical dispersion as it might be influenced by

1 a Courant number being exceeded or a Peclet number
2 being exceeded. These are one of the ways to look
3 at it and control to make sure your grid spacing
4 and time stepping is not so big that it creates
5 inaccuracies in the solution and, you know, I
6 raised it as a question.

7 I didn't know that. I had no
8 assessment that there were numerical deficiencies
9 there, but I raised it as a question. They
10 addressed it. It's in described in some of the
11 reports -- I don't remember which ones -- and
12 everything looked fine.

13 They describe that their Courant
14 number was consistently less than 1 and the Peclet
15 number consistently less than 2, and these are
16 kind of standard criteria that you want to see met
17 in solving the transport equation for groundwater.

18 Q. I guess what I'm asking is: Can
19 you -- can you point to any document or anywhere
20 where you expressed that your concerns had been
21 addressed prior to your retention as an expert in
22 this litigation?

23 MR. DEAN: Objection to the
24 form.

1 THE WITNESS: Where I -- you
2 mean where I said they were addressed?
3 BY MR. ANWAR:

4 Q. Correct.

5 A. No. I mean, I felt they were
6 addressed, but I would have no reason to write
7 that anywhere once my service on the panel was
8 done.

9 Q. And --

10 A. Which was done after my service on
11 the panel that they prepared, and so I was never
12 asked for anything until I was hired for this
13 litigation.

14 Q. And now your feelings are reflected
15 in your -- your rebuttal expert report; is that
16 right?

17 A. No. My rebuttal report is
18 commenting on Spiliotopoulos and Hennet's report.
19 It's not commenting on my original concerns.

20 Q. Okay. I noted that in a number of
21 places -- well, let me start.

22 I want to turn your attention back
23 to your -- your rebuttal report, and on page 2
24 sort of the end of your Introduction section, you

1 state:

2 "I hold these opinions to a
3 reasonable degree of scientific certainty."

4 A. At the top of the page?

5 Q. Correct.

6 Do you see that?

7 A. Yeah. Yes, I do.

8 Q. And my question is to you: What do
9 you mean there by a "reasonable degree of
10 scientific certainty"?

11 MR. DEAN: Object to the form.

12 It calls for legal conclusion.

13 THE WITNESS: Well, let me
14 read --

15 BY MR. ANWAR:

16 Q. Sure.

17 A. -- the background.

18 (Reviews document.)

19 Okay. I think to summarize what I
20 meant is that the opinions I express in here in
21 terms of critiques or reviews of what was said in
22 those expert reports, I stand behind them. I
23 think there's a scientific basis for my comments
24 and they're based on my, you know, 50 years of

1 experience as a hydrogeologist and groundwater
2 modeler and that, yeah, I stand behind these
3 opinions that are in this report.

4 Q. Okay. Are you opining that the
5 simulated monthly contaminant concentrations
6 produced by the two ATSDR models, Tarawa Terrace
7 and Hadnot Point/Holcomb Boulevard, are accurate
8 to a reasonable degree of scientific certainty?

9 MR. DEAN: Object to the form.

10 THE WITNESS: I -- I think
11 they're accurate to a reasonable degree.
12 I think they're as likely as not to
13 represent what happened.

14 There's, you know, there's a
15 band of uncertainty about the results
16 that their or the calculations by their
17 best fit parameters and best fit model,
18 but the calibrated results, I think, are
19 scientifically defensible based on
20 state-of-the-art modeling and standard
21 practices in the field of groundwater.

22 BY MR. ANWAR:

23 Q. You mention the phrase "as likely or
24 not."

1 What does that term mean to you?

2 A. It means, as far as I could tell, I
3 mean, I think I've seen that somewhere in all the
4 documents I've been reading.

5 You know, it means this could be
6 exact or maybe it's not, you know, exactly what
7 happened. But in assessing the likelihood of this
8 being right, it's just as likely to be highly
9 accurate or -- or not. It may be off, but
10 everything is done with a recognition of
11 uncertainty.

12 But these are the best estimates and
13 they're consistent with standard practices and,
14 you know, that's -- we don't know with certainty
15 that it's accurate and precise and represents
16 exactly what happened, but there's a good chance
17 that it is.

18 Q. It sounded like you were saying it's
19 as likely as it's right as it is wrong.

20 Is that what you're saying?

21 A. Well --

22 MR. DEAN: Object to the form.

23 THE WITNESS: I don't know if
24 that's exact. I won't say that's exact.

1 What I meant is, well, these
2 are good estimates and they're based on
3 scientifically defensible approaches with
4 state-of-the-art tools. There's no
5 reason not to believe them.

6 BY MR. ANWAR:

7 Q. So the phrase "as likely or not" is
8 a phrase that actually comes from the statute that
9 created this litigation.

10 A. Okay.

11 Q. And I'm just wondering: Have you
12 ever used that phrase before prior to -- to
13 your -- your expert work in this litigation?

14 A. Not that I remember. It's possible
15 I did, but I don't recall.

16 Q. Where did your understanding about
17 "as likely or not" come from?

18 A. The words. What it sounds like it
19 means.

20 Q. Did you understand that's a legal
21 standard in the statute that we're litigating?

22 A. I did not know it was a term in a
23 statute, no.

24 Q. And you're not a lawyer; right?

1 A. Absolutely not.

2 Q. And you're not offering any sort of
3 legal opinions; correct?

4 A. Nope. That's correct.

5 Q. I wanted to -- let's -- let's turn
6 to the page 32 of your report.

7 MR. DEAN: Page what?

8 MR. ANWAR: 32.

9 MR. DEAN: 32.

10 MR. ANWAR: Correct.

11 BY MR. ANWAR:

12 Q. Let's focus on -- so this is the
13 Conclusions section of your report.

14 Do you see that?

15 A. Yes.

16 Q. Okay. And that second paragraph
17 states:

18 "Although Dr. Spiliotopoulos
19 repeatedly questions the accuracy of the ATSDR
20 model and its calibration, I don't see any
21 evidence that it is unacceptably inaccurate."

22 What do you mean by "unacceptably
23 inaccurate"?

24 A. That there would be obvious errors

1 in or results that are based on errors in the
2 calibration of the model or in the use of
3 parameter values.

4 Q. Are there acceptable inaccuracies?

5 A. Sure.

6 Q. What are some of the acceptable
7 inaccuracies?

8 A. Well, I mean, if you say the
9 hydraulic conductivity is 10 feet per day, but
10 somehow our measurement says it's 12 feet per day
11 or 8 feet per day, that's an acceptable
12 inaccuracy.

13 First of all, you would never really
14 know what the true value is, and it depends on
15 many things in how you measure it, the method of
16 measurement the scale of the measurement and so
17 on. So let's say the truth is a little elusive.

18 Q. But there are inaccuracies; right?

19 MR. DEAN: Object to form of
20 the question.

21 THE WITNESS: Every model is
22 a simplification of complex reality. It
23 involves approximation, assumptions, and
24 averaging.

1 So yes, there's -- there's
2 always uncertainty and certainly errors
3 in every model, and what you try to do in
4 standard practice is assess how serious
5 those errors might be, how they might
6 affect the results.

7 You do sensitivity tests and
8 uncertainty analysis to help assess what
9 confidence you should have in the model
10 because we recognize that the model is
11 not the reality.

12 BY MR. ANWAR:

13 Q. At the bottom of the Conclusions,
14 that last paragraph that spills onto the next
15 page, you start:

16 "In my opinion, ATSDR has done an
17 admirable job in completing a challenging task of
18 using hindcasting with a calibrated model to
19 reconstruct credible concentration distributions
20 in time and space prior to the availability of
21 data from chemical analyses of groundwater samples
22 in the mid-1980s. In the face of missing
23 historical data, the ATSDR's models provide useful
24 input to epidemiological studies."

1 Did I read that correctly?

2 A. Yes.

3 Q. I think earlier we had discussed
4 -- I had asked you the purpose -- I had asked you
5 questions about the purpose of ATSDR's model and
6 the fact that the data, the information would be
7 used for epidemiological studies.

8 Do you recall that?

9 MR. DEAN: 123 now. Yeah.

10 MR. ANWAR: Okay.

11 MR. DEAN: We all do.

12 THE WITNESS: Yes, I do.

13 BY MR. ANWAR:

14 Q. And in response to some of those
15 questions, you -- you made clear you're not an
16 epidemiologist; right?

17 A. Yes.

18 Q. So what is the basis for your
19 opinion there "the ATSDR models provide useful
20 input to epidemiological studies"?

21 A. My understanding was the
22 epidemiological studies required first
23 concentrations in the water supply wells, but
24 ultimately concentrations in the water treatment

1 plants. That was my understanding of what was
2 needed, and that's my understanding of what the
3 modeling provided.

4 Therefore, I said, well, that's
5 useful. It's providing useful input. That's why
6 they wanted the models and the model -- the models
7 provided that. So my inference was that was
8 useful.

9 Q. And so if we skip a couple lines
10 ahead, there is -- starting with the fourth line
11 down, there is --

12 A. Which page?

13 Q. The last page, page 33.

14 A. Okay.

15 Q. It says:

16 "There is uncertainty in the
17 calibrated models (as there always is in such
18 models) and in the hindcasted results, and that is
19 clearly recognized and evaluated. The uncertainty
20 is not so large or unexpected as to preclude the
21 use of the model results in the epidemiological
22 studies or for providing mean monthly -- monthly
23 mean concentrations for use by health
24 professionals to estimate past exposure of

1 residents on 'as likely than not' or 'more likely
2 than not' basis."

3 Did I read that correctly?

4 A. Yes.

5 Q. Did you -- did you write that
6 sentence?

7 A. I did and those --

8 Q. Why did you -- go ahead.

9 A. You know, those terms "as likely as
10 not" or "more likely" I probably heard from the
11 lawyers and so that was -- I felt, yeah, that was
12 a good description, but they did not tell me what
13 to write or how to write it or anything like that.

14 I mean, that's probably -- I'm sure
15 I heard those terms from the lawyers, and so I
16 felt it appropriate to use it --

17 Q. Okay.

18 A. -- with, you know, my perception of
19 what that meant.

20 Q. Got it.

21 And you say:

22 "The uncertainty is not so large or
23 unexpected as to preclude the use of the model
24 results in the epidemiological studies."

1 And we talked about the
2 epidemiological studies, but then you go on to
3 say:

4 "Or for providing monthly mean
5 concentrations for use by health professionals to
6 estimate past exposure of residents on an 'as
7 likely as not' or 'more likely than not' basis."

8 You're not a health professional;
9 correct?

10 A. Correct.

11 Q. So what is -- what is the basis for
12 your opinion that the simulated concentrations
13 from the ATSDR models are -- do not preclude the
14 use by health professionals to estimate past
15 exposure of residents?

16 A. Well, from the health perspective, I
17 have no basis for saying that.

18 But from the modeling perspective, I
19 felt that the mean monthly concentrations were
20 estimated on the basis of reasonable, adequate
21 models and so that they could be relied on for
22 other purposes. But it's certainly not meant to
23 imply I understood the health studies.

24 Q. Are you offering the opinion that

1 the simulated concentrations produced by ATSDR
2 models are sufficiently accurate for health
3 professionals to rely upon?

4 A. I think they're the best that could
5 be come up with. From -- I think they're
6 reasonably accurate. I think they're reasonably
7 reliable. I think there's uncertainty associated
8 with them.

9 I think the uncertainty is clearly
10 expressed in the analyses produced by ATSDR, and
11 then it would be up to the health professionals to
12 decide with that level of uncertainty is it good
13 enough for them to use. That would not be
14 something I would say. So yeah.

15 Q. Earlier we had a discussion or an
16 exchange where I was asking you about the intended
17 purpose or use of particular models, and I believe
18 you told me, as a modeler, the use of the model
19 isn't really your focus or your concentration for
20 purposes of developing the model; is that right?

21 MR. DEAN: Object to form of
22 the question.

23 THE WITNESS: I would design
24 a model, develop the model, calibrate the

1 model according to best practices in my
2 understanding, regardless of what the
3 downstream use of that model might be.

4 Although as I said before, I
5 might refine the grid or do something
6 particular to help meet the needs of the
7 people paying for the model.

8 BY MR. ANWAR:

9 Q. But you're not -- and we -- we
10 talked -- you're not a health professional
11 yourself; correct?

12 A. Correct.

13 Q. Did you -- in forming this opinion,
14 did you speak with any health professionals?

15 A. No.

16 Q. So it's your opinion, as a modeler,
17 that the simulated concentrations from the ATSDR
18 models are -- are good enough for health
19 professionals?

20 A. Well --

21 Q. And when I say "good enough," I mean
22 accurate enough.

23 A. I think they're reasonably accurate.
24 Again, I'm not a health professional. So I

1 really -- I really shouldn't comment on whether
2 it's good enough for a health professional.

3 Q. Well, if you don't feel comfortable
4 commenting on the results being good enough for a
5 health professional, why do you feel comfortable
6 commenting on the results being accurate enough
7 for a health professional?

8 MR. DEAN: Objection to form
9 of the question. It mischaracterizes his
10 testimony 100 percent.

11 BY MR. ANWAR:

12 Q. You can answer.

13 A. Excuse me?

14 Q. You can answer.

15 A. Well, as a hydrogeologist and an
16 experienced modeler, I felt that these results
17 were reasonably reliable, and I could think of no
18 reason that they shouldn't be used in light, you
19 know, with consideration of the uncertainty, why
20 they shouldn't be used for any purpose after that.

21 Q. How many -- if you had to estimate,
22 how many groundwater and/or transport models have
23 you developed yourself or evaluated throughout
24 your career?

1 A. Probably on the order of half a
2 dozen comprehensive, detailed studies and model
3 developments that I've done. And in terms of
4 reviewing or assessing others, probably many tens,
5 if not well over a hundred different cases,
6 probably even more.

7 Q. Of all those models, are ATSDR
8 models -- are ATSDR's models the only one you're
9 aware of that are -- that estimate -- that are
10 attempting to be used to estimate exposure --
11 monthly contaminant concentrations for exposure
12 determinations in individuals?

13 MR. DEAN: Object to the form.

14 BY MR. ANWAR:

15 Q. You can answer.

16 A. Well, as I mentioned earlier, the
17 analyses for the Waste Isolation Pilot Plant used
18 models for 10,000 years into the future, and that
19 was for the purpose of health exposure of a
20 potential hypothetical future farmer and so it was
21 used for health assessments. I don't recall what
22 the health assessment studies were or how they
23 were done, but it was used. That was one of the
24 purposes of that modeling.

1 There are many other models that I
2 reviewed with similar characteristics, but most
3 often I say they do not describe what the sponsors
4 of the modeling effort were going to do with it.
5 So a lot of times.

6 So I guess my answer is, they may or
7 may not have been used for health exposure
8 studies. I don't know because I wasn't always
9 aware of what the ultimate purpose of the model
10 was.

11 Q. Okay. There are places in your
12 report -- and I can give you examples if you'd
13 like -- where you -- so, for instance, on the page
14 we were just looking at, the last line of your
15 report, you state:

16 "The methods were rigorous and
17 scientifically sound."

18 Correct?

19 A. Yes.

20 Q. And then there are other places
21 throughout your report where you refer to
22 scientifically valid methods being used and/or the
23 models being scientifically valid, the ATSDR
24 models.

1 Do you recall that?

2 A. I don't recall saying they were
3 scientifically valid, but I may have said that.

4 Q. Okay. Well, why don't we -- why
5 don't you turn to page 30 of your report.

6 A. 30?

7 Q. Yeah.

8 A. Okay.

9 Q. Sorry. I might have put the wrong
10 page on. Give me a second.

11 Oh, I'm sorry. Yeah. It is
12 starting on 30.

13 At the bottom of 30, that last
14 paragraph has a section heading "Section 3.3 and
15 scientific validity of ATSDR model -- ATSDR's
16 models," and you quote an opinion offered by
17 Dr. Spiliotopoulos there where he -- he opined:

18 "I do not think their results were
19 scientifically valid because" -- or I think you
20 quote Dr. Waddill, actually.

21 A. Yes.

22 Q. And it says:

23 "I do not think their results ...
24 were scientifically valid because, you know,

1 science needs to be based on real-world
2 observations and analysis ... and there were just
3 not enough real-world measurements for this to
4 count as scientifically valid."

5 And you disagree there.

6 And then on the next page, on page
7 31, the second line:

8 "Therefore, I would counter
9 Dr. Waddill's statements by noting that in
10 developing and applying the ATSDR groundwater
11 models, that scientifically valid methods were
12 used, and the models were based on sound hydraulic
13 and physical principles that themselves have been
14 tested and shown to be accurate and reliable
15 approaches to describing and predicting
16 groundwater flow and contaminant transport."

17 Did I read that correctly?

18 A. Yes.

19 Q. Okay. Is it your opinion that
20 ATSDR's Camp Lejeune water models are
21 scientifically valid?

22 A. Yes.

23 Q. Why do you say that?

24 A. The models are based on a

1 mathematical representation of the processes that
2 govern fluid flow in porous media and the movement
3 of dissolved chemicals. These equations are well
4 accepted throughout the scientific and engineering
5 worlds.

6 There's common practice, standard
7 practice. There may be some debate in the
8 scientific circles, particularly about the
9 governing solute transport equation, what it
10 should look like but, nevertheless, it is a
11 standard form. And these equations and the
12 numerical methods to solve them are widely
13 accepted as being scientifically valid and
14 appropriate and useful.

15 So these -- these are the models and
16 methods that ATSDR used and applied and, you know,
17 I think what they do is estimate how water fluxes
18 and water levels and solute concentrations, how
19 they change over time in a way that is consistent
20 with the widely accepted principles reflected in
21 the governing equations.

22 This is -- this is valid science.
23 This is, you know, well accepted. You know,
24 there's very few people that would argue with

1 that, you know. So I think, yes, it is
2 scientifically valid.

3 MR. ANWAR: Okay. I'm going
4 to hand you an exhibit that I'm marking
5 as Exhibit 14.

6 (Document marked for
7 identification as Konikow Exhibit 14.)

8 BY MR. ANWAR:

9 Q. This is an editorial that was
10 coauthored by you and a J.D. -- you pronounced it
11 earlier -- Bredehoeft?

12 A. Bredehoeft.

13 Q. Bredehoeft. Entitled "Ground-Water
14 Models: Validate Or Invalidate"; correct?

15 A. Correct.

16 Q. And we can -- we can read through
17 this a little bit, but the first bolded section
18 there -- so it was originally -- let me take a
19 step back.

20 This editorial was originally
21 published in 1993; correct?

22 A. The editorial? It says reprinted
23 from 1993. The ideas expressed in here are really
24 based on a more comprehensive analysis and article

1 that Bredehoeft and I published in, I believe,
2 1992.

3 Q. Okay. What is the name of that
4 publication?

5 A. I think it was "Advances in Water
6 Resources" is the name of the journal.

7 Q. And then this editorial was
8 republished in "Groundwater" in 2012; correct?

9 At the bottom note.

10 A. Yes.

11 Q. So the first paragraph focuses on
12 validation and it states:

13 "The word validation has a clear
14 meaning to both the scientific community and the
15 general public. Within the scientific community
16 the validation of scientific theory has been the
17 subject of philosophical debate."

18 And then you reference Karl Popper.

19 Going to the second paragraph there,
20 you state:

21 "To the general public, proclaiming
22 that a ground-water model is 'validated' carries
23 with it an aura of correctness that we do not
24 believe many of us who model would claim. We can

1 place all the caveats we wish, but the public has
2 its own understanding of what the word implies.
3 Using the word 'valid' with respect to models
4 misleads the public; 'verification' carries with
5 it similar connotations as far as the public is
6 concerned.

7 "Our point is this: using the terms
8 'validation' and 'verification' are misleading, at
9 best. These terms should be abandoned by the
10 ground-water community."

11 Did I read that correctly?

12 A. Yes.

13 Q. And so when you're describing
14 ATSDR's model as scientifically valid --

15 A. I never said that their model was
16 valid. I never said it was validated. I never
17 said anything about validation of the models.

18 I said the -- I try to avoid using
19 the term "valid" or "validation." I used it once
20 or twice in terms of overall broad scientific
21 validity reflecting that it's a widely accepted
22 method.

23 Q. I think I just asked you the
24 question, is it your opinion that ATSDR's models

1 are scientifically valid, and your response was
2 yes.

3 Is it?

4 A. Well, okay, but, you know, if you
5 read the paper, what I don't want to imply is that
6 the model is perfect or that there is no other
7 model within the realm of infinite possibilities
8 of combinations of parameters that would not do as
9 well in terms of accuracy.

10 So it's not a unique model. It's
11 valid in a broad sense of that term, but there is
12 no exercise that validated their model. But it's
13 valid scientifically in the sense of using
14 state-of-the-art methods.

15 Q. What do you mean "there was no
16 exercise that validated ATSDR's models"?

17 A. They went through a calibration,
18 which involved history matching, and that
19 calibration yields a best fit to the parameters,
20 but it's not the only possible fit. History
21 matching by itself does not prove that the model
22 was valid, that it was the absolute truth.

23 We know it's not. That's why we do
24 uncertainty analysis and sensitivity analyses.

1 Q. Your -- your report is directed to
2 an audience of people that are not modelers;
3 correct?

4 A. Which report are you referring to?

5 Q. I'm sorry. Your rebuttal expert
6 report in this case; correct?

7 It's directed towards an audience
8 that all aren't necessarily modelers; correct?

9 A. Yeah. I mean, it's aimed at you and
10 others that aren't hydrogeologists, as well as
11 aimed at technical experts in hydrogeology.

12 Q. Isn't using the terms "valid
13 methodology" or "scientifically valid" or
14 describing the model as "valid," isn't that, as
15 you state in your own words here, misleading?

16 MR. DEAN: Object to the form
17 of the question.

18 THE WITNESS: Well --

19 MR. DEAN: Mischaracterizes
20 his prior testimony. He's already
21 answered that question.

22 THE WITNESS: Let me
23 emphasize that bringing up this topic of
24 validity was not mine. It was brought

1 up -- I'm quoting from Spiliotopoulos.

2 He raised the issue and so I'm trying to
3 address it.

4 It is not -- it's not a
5 terminology that I would normally use for
6 the very reasons we discussed and
7 summarized in that editorial.

8 BY MR. ANWAR:

9 Q. And the first sentence of that
10 second paragraph:

11 "To the general public, proclaiming
12 that a ground-water model is 'validated' carries
13 with it an aura of correctness that we do not
14 believe many of us who model would claim."

15 "Using the word 'valid' with respect
16 to models misleads the public."

17 Isn't describing ATSDR's models as
18 scientifically valid or the methodology they used
19 as scientifically valid, isn't that intended to
20 carry with it an aura of correctness that you
21 acknowledge?

22 A. I don't think they ever said that
23 they validated their model. I don't think that
24 terminology was ever used with respect to their

1 modeling of the results.

2 The ATSDR is very clear and very
3 transparent about recognizing uncertainty in the
4 results.

5 Q. They -- go ahead.

6 A. So they're not anywhere in my
7 reading implying that they have the right truth or
8 model or that they validated it in the sense of it
9 being the ultimate pinnacle of correctness. I
10 don't think they ever implied that. They
11 certainly never say that, and I think that's why
12 we use.

13 What they've done clearly in many,
14 many, many plots of results, they show the
15 calculations based on their best fit calibrated
16 model, and they show upper and lower bounds about
17 that that reflect some range of consideration of
18 uncertainty in one or more parameters.

19 So I think they're very clear in
20 expressing that they have not validated the model
21 in the sense that people could misinterpret it to
22 mean that they have an aura of correctness and
23 certainty about their results.

24 Q. ATSDR didn't validate their model

1 because they couldn't validate their model; right?

2 MR. DEAN: Object to the form
3 of the question.

4 BY MR. ANWAR:

5 Q. There wasn't sufficient data to
6 validate their model; correct?

7 MR. DEAN: Object to the form.

8 THE WITNESS: That's very
9 misleading as I read it because there is
10 never ever any groundwater model for
11 which there is sufficient data to say
12 (indicates) you've validated it. It just
13 doesn't exist.

14 There is always uncertainty.

15 Every model ever developed for
16 groundwater has uncertainty associated
17 with it, and no competent hydrogeologist
18 would claim that they have the truth.

19 BY MR. ANWAR:

20 Q. What is your understanding of why
21 ATSDR didn't validate their models?

22 MR. DEAN: Object to the form
23 of the question.

24 THE WITNESS: Repeat the

1 question.

2 BY MR. ANWAR:

3 Q. What -- having reviewed the reports,
4 the Tarawa Terrace reports and the Hadnot
5 Point/Holcomb Boulevard reports in preparing for
6 your deposition and offering expert opinion in the
7 case, why didn't ATSDR just validate their two
8 models?

9 A. Well, the title of the paper I
10 published in 1992 with John Bredehoeft is
11 groundwater models cannot be validated. That did
12 not refer to ATSDR or Camp Lejeune. It referred
13 to every groundwater model ever developed or
14 potentially developed in the future.

15 It's in our opinion -- and not
16 everyone agrees, but in our opinion, no
17 groundwater model could be validated in the sense
18 that the public might perceive the term to imply
19 that you have the right model to the exclusion of
20 any other possibility.

21 So if ATSDR had claimed that they
22 validated the model, I would have come down on
23 them very hard, severely criticized them for
24 saying that, but I think they knew better than to

1 say that.

2 Q. Okay. Describing a groundwater --
3 groundwater model as scientifically valid or the
4 methodology that was used as being scientifically
5 valid doesn't mean that the output, in this -- in
6 this case the simulated concentrations produced by
7 ATSDR's models, are accurate; right?

8 MR. DEAN: Object to the form.

9 THE WITNESS: It depends how
10 you mean "accurate." They're not
11 precisely the truth because we don't know
12 the truth. They're not, you know,
13 they're reasonable and they represent
14 what's going on, but there's uncertainty
15 about it.

16 It could be a little higher.

17 It could be a little lower. This is the
18 best estimate in the middle. It's a
19 moving trend based on a very reasonable
20 model that solves the governing
21 equations.

22 The equations for which we
23 know represent the processes, but the
24 coefficients in the equation are not

1 known precisely, and they are never known
2 precisely or accurately.

3 BY MR. ANWAR:

4 Q. Okay. I think you stated or I
5 believe it's listed on your reliance materials
6 that you reviewed Jones and Davis's original
7 postaudit report; correct?

8 A. I read it. It was probably a couple
9 of weeks ago. I didn't give it a technical review
10 in great depth, but I did. I looked at it, yeah.

11 Q. Did you also look at their -- I
12 can't recall, so I apologize if I asked you this
13 already.

14 Did you also look at their rebuttal
15 expert report submitted in this case?

16 A. I think I did, yes.

17 Q. There is a portion in their report
18 where they state:

19 "Based on this postaudit, we can
20 find no significant evidence that would invalidate
21 the analysis performed by ATSDR with the original
22 model."

23 Are they using the term "invalidate"
24 then incorrectly?

1 MR. DEAN: Object to the form.

2 THE WITNESS: Well, I would
3 assume so. You know, the general belief,
4 John Bredehoeft and I and many others
5 believe that you can invalidate a model,
6 but you cannot validate it. And by
7 invalidating, you show that there are
8 significant errors from what's going on.

9 So if you -- the basic
10 reasoning -- I'm not sure who said this
11 first but, you know, if you have a model,
12 you have best fit, your history match,
13 and all of that. That builds confidence
14 in the model, but it doesn't prove you
15 have a valid model.

16 If you make a prediction and
17 that prediction turns out to be wrong by
18 some substantial degree, you have in
19 effect invalidated the model and you try
20 to get a better model.

21 But if the next prediction,
22 you know, that prediction you made turned
23 out to be really close, that builds more
24 confidence, but it still doesn't prove

1 that you validated the model because the
2 very next prediction might be erroneous.

3 So the kind of philosophy --
4 philosophical argument is that you can
5 never validate the model in any kind of
6 literal sense, but you can invalidate it
7 by showing that it was inaccurate.

8 BY MR. ANWAR:

9 Q. Isn't validation a history matching,
10 a form of history matching?

11 A. What I would argue is that they are
12 not equivalent. History -- if you match history
13 very well, that doesn't mean you validated the
14 model. It means you have more confidence in the
15 model. The model is probably pretty good.

16 Q. If you have history matched very
17 well, why does that not validate the model?

18 A. Because the next prediction could be
19 off. You may not have data for a particular point
20 or thing where it may have been an error. You
21 never have enough to say, this is the perfect
22 model and it's a valid model or you validated it.
23 Because you make a prediction, that could turn out
24 to be wrong.

1 So the general cautiousness that you
2 want to say is that you've got a good model, a
3 reasonable model. We've matched the history, the
4 historical data that we have. We have a good
5 calibration, and we think this is an appropriate
6 model, a reasonable model for the purposes that
7 we're using it.

8 But we don't say that it's validated
9 because I would argue that you can never validate
10 a model because you never, you know, you just
11 don't know what will happen in the future.

12 Q. So my understanding of calibration
13 and validation is -- and you should correct me if
14 I'm wrong -- is essentially that you -- when
15 you're calibrating the model, you're attempting to
16 adjust parameters to match observed parameters
17 such that the simulated results matches closely as
18 possible observed values that you're running the
19 model against.

20 And validation is taking a set of
21 observed values that you didn't use as part of the
22 calibration and then comparing the simulated
23 models against sort of a separate set of observed
24 data.

1 Is my understanding right?

2 A. I would say it's not right, but it
3 matches the perception of many other people. You
4 know, I think there are people who believe that.

5 I would counter that in groundwater
6 systems, you can almost never have independent
7 data sets. If you have, you know, your
8 observations say, well, let's save this for the
9 (indicates) what you might call validation, you're
10 not blind to that data. You know what it is.

11 It's not.

12 You know, in drug approval, they
13 would never say that that's acceptable for a drug
14 test because you are aware of what those values
15 were. You weren't blind to them, and they're not
16 an independent set of data.

17 You never have an independent set of
18 data in a historical groundwater. Everything is
19 linked and in groundwater systems, even if you can
20 compare it with surface water systems, surface
21 water, without the issue of validation, you could
22 get a fairly independent set of responses in a
23 river flow data if you go down a year or two in
24 time in response to different precipitation

1 events.

2 In groundwater systems, the
3 responses are much more buffered and much more
4 slower, and the behavior of a groundwater system a
5 year in the future depends to a large degree on
6 what it was at the start of that year.

7 You don't get independence and that
8 restricts your ability to even talk about
9 validation with an independent data set because
10 it's so difficult to get in groundwater system
11 anything that approaches an independent data set,
12 and I would argue that still revealed validation
13 if you had.

14 Q. I guess the reason I asked -- part
15 of the reason I asked that question: If it's your
16 opinion that you can't validate a model ever under
17 any circumstance, how can you ever calibrate a
18 model? How can you say that any model --

19 A. The calibration has nothing to do
20 with validation in the sense. You can calibrate.
21 What you do in model calibration is adjust
22 parameters and boundary conditions and maybe some
23 other processes, maybe your numerical grid, maybe
24 your time step. You adjust lots of things so that

1 the results match the historical changes that
2 you've seen. You could do this. It doesn't
3 depend on any condition (indicates) called
4 validation.

5 It's the process of model
6 calibration is the process of parameter
7 restoration in effect, and that's why automatic or
8 automated parameter estimation models are so
9 useful because they make the whole process faster
10 and more efficient to adjust parameters to get
11 what could be a statistically best fit.

12 Q. Is it possible to adjust the
13 parameters in a model in such a way that
14 the -- that you successfully -- let me -- let me
15 start -- strike that.

16 Talk to me about the concept of
17 nonuniqueness.

18 MR. DEAN: Object to form.

19 THE WITNESS: Excuse me?

20 MR. DEAN: Object to form.

21 BY MR. ANWAR:

22 Q. What is nonuniqueness in modeling?

23 A. Well, that's basically the concept
24 that when you calibrate a model, you have a set of

1 parameters that you feel give you the best fit but
2 that may not be the only combination of parameters
3 that give you approximately an equally good fit.

4 You know, there's, you know, if
5 you -- if your result is a sum of 10, 5 plus 5
6 gives you 10 or 6 plus 4 gives you 10, and in
7 terms of the fit, they're both equally good.

8 Q. And so when we're talking about
9 calibrate -- adjusting parameters to calibrate a
10 model, there -- there are many different
11 possibilities of combinations of parameters that
12 could calibrate the model in the sense that the
13 simulated values match the observed values;
14 correct?

15 A. As well as possible. What you do
16 that -- I mean, it's not an unbounded process.
17 What you do is you consider the -- how good the
18 fit is and the quality and the errors and the mean
19 error and all the other statistical measures of
20 the fit. And you adjust parameters until that
21 error measure gets smaller and smaller, and
22 continued changing of parameters basically yields
23 no improvement, no further improvement in fit, and
24 that's why you say, well, that's as good as we

1 could do.

2 Q. And simply calibrating a model or --
3 excuse me -- simply adjusting parameters in a way
4 that to calibrate a model doesn't mean the model
5 is good or accurate if the input parameters are
6 unrealistic; correct?

7 A. Well, one of the guidelines for
8 adjusting parameters during history matching
9 during calibration is you have to keep those
10 bounded within reasonable limits. You know,
11 that's, you know, whether you're doing by trial
12 and error or with an automated method, you don't
13 have an unlimited range to adjust parameters.

14 You can't have a negative value of
15 hydraulic conductivity. You know, you have to be
16 consistent with principles and your geologic
17 knowledge and other maybe more subjective
18 criteria, but it's not an unbounded universe.

19 Q. The statistical analysis that you're
20 talking about to -- to ensure that the model is
21 appropriately calibrated and the parameters fall
22 within a certainty bound, ATSDR didn't do that
23 statistical analysis for the Hadnot Point/Holcomb
24 Boulevard model; right?

1 A. I'm not sure what you mean. I mean,
2 they did a model calibration. They were measuring
3 the goodness of fit. They -- my understanding is
4 that they used the PEST software to help with the
5 calibration and parameter. That PEST
6 automatically calculates all those measures of fit
7 and that's how it does the calibration, by
8 minimizing some objective function that's related
9 to the error.

10 Q. Okay. Why don't we take a quick
11 break.

12 A. Sure.

13 MR. ANWAR: A short break.

14 THE VIDEOGRAPHER: Going off
15 the record. The time is 3:51 PM.

16 (A recess was taken.)

17 THE VIDEOGRAPHER: We're back
18 on the record. The time is 4:05 PM.

19 BY MR. ANWAR:

20 Q. We are back on the record from a
21 short break.

22 Dr. Konikow, are you okay to
23 continue?

24 A. Yes.

1 Q. Okay. And did you speak with your
2 lawyers about the substance of your testimony?

3 A. No.

4 Q. Okay. I wanted to ask you.
5 Can a postaudit be used to validate
6 a model?

7 A. No.

8 Q. Why not?

9 A. Because a model can't be validated.

10 Q. And looking back at your -- this
11 editorial, it is, I think, Exhibit 13.

12 A. 14.

13 Q. 14. Thank you.

14 If you turn to the next page, there
15 is a section on Postaudits, and you state there:

16 "Several postaudits have been
17 performed to evaluate the accuracy of predictions
18 made using -- sorry, lost my place -- made using
19 supposedly validated -- 'validated' models.
20 Compared to the number of model studies, the
21 number of postaudits is small. There are numerous
22 problems in examining past predictions; often the
23 stress placed on the system was quite different
24 from that used in the model analysis.

1 "The results of the current set of
2 postaudits suggests that extrapolations into the
3 future were rarely very accurate. There are
4 various problems with the models: the period of
5 history match was too short to capture an
6 important element of the model, or the conceptual
7 model was incomplete, or the parameters were not
8 well-defined, etc. Our experience suggests that
9 models are more useful as tools used by the
10 hydrologist to understand the system rather" -- it
11 says "that" but I think it's -- "than as tools to
12 predict future response. Our record of
13 'validating' models is not encouraging."

14 Did I read that correctly?

15 A. Yes.

16 Q. Okay. So you can use a postaudit to
17 evaluate the accuracy of the predictions of a
18 model; correct?

19 A. No.

20 MR. DEAN: Object to form.

21 THE WITNESS: That's not
22 correct.

23 BY MR. ANWAR:

24 Q. Okay.

1 A. You could use the postaudit to
2 assess the accuracy of the predictions made by the
3 model, how good the model was, but it just would
4 not prove that you had a valid model.

5 Q. Okay. And why -- why wouldn't it
6 prove that you have a validated model?

7 A. Because if you use the model, the
8 same model to predict another year into the
9 future, that may be very wrong. That prediction
10 may be wrong and, therefore, that would prove you
11 had an invalid model. It would invalidate the
12 model.

13 So when you use a postaudit to
14 assess the accuracy of the prediction, if it turns
15 out -- which doesn't always happen -- if it turns
16 out that the prediction was fairly reliable and
17 acceptably accurate, it helps build confidence in
18 the model. You're building confidence in the
19 model. You feel better about the model.

20 You just have not proved that it is
21 a valid model. You have not validated the model
22 because the next prediction could be very much in
23 error with the same model, and that would
24 invalidate the model.

1 Q. Okay. Understand.

2 Can you pull up Exhibit 12. It is
3 the 2005 transcript of the expert summary, day 2.

4 A. Which one is 12?

5 Q. It's the transcript of the expert
6 panel. I think we have only given you one of
7 those so far. Should be one of the thick ones.

8 A. Yeah, thick ones. This is 9. 13.

9 Q. There you go.

10 A. 12. Okay.

11 Q. Could you turn to page 46?

12 A. Okay.

13 Q. Okay. So just for frame of
14 reference purposes, the 2005 expert panel was
15 focused on ATSDR's Tarawa Terrace model; correct?

16 A. Yes.

17 Q. And so starting at line 14, there's
18 a discussion going on and you chime in at line 14.
19 You say:

20 "But the point -- one of the points
21 is that you really -- your study isn't starting
22 until 1965."

23 And Maslia says '68 and you say '68.

24 "That gives you 14 years from the

1 time ABC Cleaners started. So the value in doing
2 the groundwater flow and transport model will be
3 to, you know, start as best as we -- or as best we
4 know. They were introducing contaminants into the
5 soil at least through the septic tanks very
6 shortly after they started, maybe a year, maybe
7 instantly, maybe a year, maybe two years at most.
8 That gives you 12 years for it to reach the water
9 table and spread."

10 "The" -- going into the next page.

11 "The groundwater flow and transport
12 models accounting for uncertainty" --

13 A. I'm not sure where you're reading
14 from now.

15 Q. On page 47 line 1.

16 A. Okay. Okay.

17 Q. Just continuing from where we were
18 reading.

19 "The groundwater flow and transport
20 models accounting for uncertainty, heterogeneity,
21 and so on will give you a range of arrival times,
22 but I'm guessing the bulk of your realization will
23 get contaminant reaching the wells in that 14-year
24 period."

1 Did I read that all correctly?

2 A. Yes.

3 Q. And it sounds like in this exchange,
4 you're talking about here mass loading at Tarawa
5 Terrace; correct?

6 A. Well, we're talking about, yeah, the
7 solute load. Yeah, when the source got to the
8 water table and then spread down to TT-26 and so
9 on.

10 Q. And the way I read your comments
11 here is that, you know, you say:

12 "ABC Cleaners, they were introducing
13 contaminants into the soil at the very least
14 through the septic tanks very shortly after they
15 started, maybe a year, maybe instantly, maybe a
16 year, maybe two years at most. That gives you 12
17 years for it to reach the water table and spread."

18 You're discussing --

19 A. I did not mean that it would take 12
20 years to reach the water table.

21 Q. Okay.

22 A. I meant that it would reach the
23 water table, and then it had 12 years to spread.
24 Until that, you know, 1968 time.

1 Q. It does sound like you're saying
2 here, though, that the contaminants wouldn't reach
3 the water table on day one; right?

4 A. On day one? Probably not.

5 Q. And you indicate that "maybe a year,
6 maybe two years at most"?

7 A. Yeah, I really think it would be
8 less than that.

9 Q. But at this time, you stated "maybe
10 a year, maybe two years at most"; right?

11 A. Yeah, that's what I said. Yeah.

12 Q. And, again, when you're referencing
13 1968, you're talking about the starting point of
14 the EPI study that ATSDR was performing; right?

15 A. I believe so.

16 MR. ANWAR: Okay. I'm going
17 to hand you what I'm marking as
18 Exhibit 15.

19 (Document marked for
20 identification as Konikow Exhibit 15.)

21 BY MR. ANWAR:

22 Q. This is the transcript from day 1 of
23 the 2009 expert panel; right?

24 A. Apparently, yes.

1 Q. And it's dated April 29, 2009 there;
2 correct?

3 A. Yes.

4 MS. BAUGHMAN: Did you hand us
5 one?

6 MR. ANWAR: Yeah, it's right
7 there.

8 BY MR. ANWAR:

9 Q. I'd like you to turn to page 89.
10 And in the middle of the page there,
11 your name is highlighted starting on line 7.

12 Do you see that?

13 A. Line 7.

14 Q. On page 89?

15 A. Yes.

16 Q. You see that?

17 A. Yes.

18 Q. It says:

19 "DR. KONIKOW: The Tarawa Terrace
20 with the first arrival in November '57, if that
21 was actually several years later, maybe even four
22 or five years later, would that have any effect on
23 the health study since the health study is '68 to
24 '85?"

1 Did I read that correctly?

2 A. You read it correctly.

3 Q. And so you're -- you're raising
4 whether an even later contaminant mass loading
5 date would impact the -- the EPI study that ATSDR
6 was performing; correct?

7 MR. DEAN: Object to the form.

8 THE WITNESS: I seem to be
9 talking about the first arrival, and I am
10 inferring that might be talking about
11 TT-26, but I don't see. I haven't
12 carefully read right now the preceding
13 several pages.

14 So when I said "first
15 arrival," I'm inferring that meant at
16 TT-26, but I'm not positive that's what
17 we were talking about.

18 BY MR. ANWAR:

19 Q. Okay. TT-26, was that the -- was
20 that the primary source in Tarawa Terrace?

21 A. I believe so.

22 Q. Or that was the source was ABC
23 Cleaners, but the TT-26 was the most contaminated
24 well; correct?

1 A. Most contaminated well, yes.

2 Q. Okay. And so if we go on to read,
3 Mr. Maslia states:

4 "We actually did, Mustafa Aral did
5 some well scheduling optimization and did
6 different scenarios with different wells other
7 than the ones that we calibrated for the model.
8 And you could shift from '57 to '60, but during
9 the course of the study it did not significantly
10 affect at all the higher concentrations.

11 "They all tended towards that level
12 of that chart, the graph that shows in the
13 finished water that all that it shifted was, other
14 than if you shut down, for example, TT-26. If you
15 shut down TT-26, both the data and the model would
16 show that your finished water went down to
17 practically no contamination at Tarawa Terrace.
18 But if you shifted the cycling so that it didn't
19 hit or arrive or pass the MCL, say, as you said,
20 59, 60, 61, whatever, did not significantly affect
21 the higher concentrations in the finished water."

22 Did I read that correctly?

23 A. Yes.

24 Q. Okay. And because TT-26 was the --

1 I guess the most contaminated well, it sounds like
2 he's saying -- Mr. Maslia -- that if you shut it
3 down, the contamination levels went to nearly
4 zero; correct?

5 A. He said that they would. He didn't
6 say they shut it down. He said -- I believe he
7 implied if you shut down TT-20 -- TT-26. That was
8 because that was the main source, not the only but
9 the main source, of contaminated water to the
10 Tarawa Terrace Water Treatment Plant. If that
11 wasn't pumping, then there would be few, very few
12 contaminants showing up in the Water Treatment
13 Plant.

14 I think that's what was implied
15 there.

16 Q. Do you recall the extent of data
17 available about the pumping history for TT-26?

18 A. I recall seeing it. I can't recite
19 the details of it, but I know they had a graph
20 showing when it was operating, and there was
21 another graph showing estimated pumping rates from
22 that and other wells. So yeah.

23 Q. Would you agree that there was
24 incomplete data about the pumping history of

1 TT-26?

2 MR. DEAN: Object to form.

3 THE WITNESS: To the best of
4 my knowledge, there was not a complete
5 record of when the well was pumping and
6 how much it was pumping. That had to be
7 reconstructed also.

8 BY MR. ANWAR:

9 Q. And one of the assumptions that
10 ATSDR made was to assume that the well was pumping
11 unless there was a historical record confirming
12 that the well was not pumping; correct?

13 A. Well, I don't know exactly what they
14 assumed but, you know, certainly in terms of, they
15 had methods to estimate what the average monthly
16 pumping rate was. And if the well is shut down
17 for a day or two during a particular month, then
18 maybe your average withdrawal for that month would
19 be a little lower.

20 But for the model, you would still a
21 sum -- assume that it's pumping at that slightly
22 lower rate but over the whole month, and it
23 wouldn't make any significant difference in the
24 results.

1 But as I recall, there were only two
2 extended periods of non-operation of TT-26 before
3 it was finally shut down, but I don't think that
4 implied that it was never shut down. I think
5 there was some statement that typically they cycle
6 through all the different wells that supplied
7 water, and so it was routine for any individual
8 well to be shut down for a short period of time.

9 I think that's normal when you have
10 multiple wells in a well field supplying it. I
11 think it's normal to cycle through using different
12 ones to meet the demands at the time.

13 Q. Okay. And so your recollection of
14 the way ATSDR handled -- handled the model with
15 respect to missing pumping history is that they
16 cycled through?

17 A. No, that wasn't part of the
18 reconstruction. That was part of the operation.

19 That the normal operation of wells,
20 I believe, included cycling through different
21 combinations of well pumping at any time, any
22 particular time during the whole history, in other
23 words.

24 So no one is saying that, the

1 Department of the Navy or anyone. They're not
2 saying that TT-26 pumped continuously from the
3 beginning to end of their pumping period before
4 there was, you know, a longer break for servicing.

5 The normal operation includes short
6 sequences in which the well is turned off, maybe
7 minor servicing, but that's normal and it doesn't
8 affect the model.

9 Q. How did ATSDR handle TT-26 for
10 purposes of the historical reconstruction period?

11 A. You mean --

12 Q. The pumping. How did ATSDR handle
13 the pumping schedule for TT-26 for purposes of the
14 historical reconstruction period dating back to
15 1953?

16 A. I don't have a precise recollection
17 of method they used, but it was well-documented in
18 the report. I had read it. I just don't recall
19 the details of it, but my recollection is that
20 there was some estimates based on water demand,
21 you know, how much the water treatment plants
22 needed, and how that might have been apportioned
23 among the different wells supplying it.

24 So there was some correlation,

1 regression analysis and reconstruction, and it
2 is -- let me emphasize again that in all
3 groundwater models, you require an estimate of the
4 pumpage from all wells in the area and it is, I'd
5 say, beyond common, it's almost in every case the
6 models have to reconstruct the pumping history and
7 make estimates of it.

8 Q. Understood.

9 A. It is rare that over a historical
10 period you would have very precise records of
11 pumpage.

12 Q. Let's turn to page 201, and starting
13 at line 6 your name is highlighted there for
14 comments you made; correct?

15 A. Yes.

16 Q. Okay. So it says:

17 "DR. KONIKOW: So then the question
18 is how do you go, you'll calculate a mass, but
19 then how do you go back in time and use that to
20 estimate what the mass loading rate is over the
21 duration of the model? The Tarawa Terrace
22 situation you had essentially a point source with
23 a known location and a fairly constant -- constant
24 over time disposal rate. Here I'm not sure how

1 you're going to reconstruct the history of mass
2 loading."

3 You're referring to Hadnot Point and
4 Holcomb Boulevard; right?

5 A. I believe so.

6 Q. Why are you not sure how they're
7 going to reconstruct the history of mass loading
8 at Hadnot Point and Holcomb Boulevard?

9 A. Well, I wasn't sure because there
10 were multiple sources. There was very little
11 record. There were underground storage tanks that
12 were leaking. They could discover where they were
13 but not necessarily when they started leaking.

14 There were aboveground storage
15 tanks. There were poor practices in industrial
16 facilities. There was -- there were, you know,
17 just multiple potential sources, and this was a
18 logical question, I thought. How are you going to
19 reconstruct it?

20 Well, I mean, they went ahead and
21 reconstructed it, and they documented the methods
22 they used and, you know, I mean, they did it.
23 There's uncertainty associated with that.

24 MR. ANWAR: All right. Okay.

1 I'm going to hand you a different
2 exhibit. Fortunately, it's another one
3 of these big transcripts. I am marking
4 this exhibit as Exhibit 16.

5 (Document marked for
6 identification as Konikow Exhibit 16.)

7 BY MR. ANWAR:

8 Q. Now, in your report, quickly jumping
9 back to Exhibit 2, on page 9, it is -- yeah, on
10 page 9, you include a graphic F16 from the Tarawa
11 Terrace reports.

12 Do you see that there?

13 A. Yes.

14 Q. Why did you include that graphic?

15 A. (Reviews document.)

16 Well, reading back, it looks like
17 Dr. Spiliotopoulos included that in his report,
18 and I wanted to discuss it. So I thought it might
19 be of value. I didn't include too many figures in
20 my report, but this is one I thought was worth
21 including.

22 It --

23 Q. Go ahead.

24 A. Do you want me to comment on that

1 figure or...

2 Q. Sure.

3 A. Well, as I say here, he's commonly
4 talking about the model being biased high or that
5 the estimates were biased high in it. You know, I
6 think he, you know, sort of cherry-picking results
7 that emphasize that and ignoring the results that
8 might counter it.

9 To me this, the figure that
10 apparently he used in his report, is really the
11 kind of results you want to see. The simulated
12 results at the time of five of these observations
13 falls right about a level of 800 when the
14 observations range from about -- I don't know -- 3
15 or 30 up to about almost 1600. That is the
16 simulated value falls right in the middle of that
17 range, and to me that's a good estimate of -- a
18 good illustration of where the model is doing a
19 really good job.

20 It's -- that's, you know, when
21 you're faced with the variability in the observed
22 data over such a short time at one point in time,
23 which sometimes it's hard to explain but,
24 nevertheless, there it is. You can't expect the

1 model with monthly time steps to match every
2 single one of those values. You want it to match
3 the central tendency of those values, and that it
4 did almost perfectly.

5 Q. Is it your opinion that this F16
6 figure shows a well-calibrated model?

7 A. Well, that it seems to be. It
8 certainly is not evidence of anything being biased
9 high.

10 And one of the things to note is
11 that this is the record at TT-26, which was the
12 most important water supply well in terms of
13 contributing contaminants to the Water Treatment
14 Plant.

15 If you could have said, without
16 seeing the simulated results, where would you have
17 wanted the model to be at that point in time, I
18 would say right at 800.

19 Q. And so it's your opinion that --
20 just to be clear, it's your opinion that Figure 16
21 shows TT-26 at least -- let me -- let me ask that
22 again.

23 Is it your opinion that with respect
24 to TT-26 the model -- this figure demonstrates the

1 model is calibrated well?

2 A. At least at that point. Again, it
3 doesn't prove there's a perfect match everywhere.
4 It's just at this point, boy, you couldn't do any
5 better. That's an important point. That location
6 is an important location.

7 Q. Okay. Let's -- is it your opinion
8 that ATSDR's Tarawa Terrace model does not
9 overestimate contaminant concentrations?

10 A. I think there was evidence at some
11 locations that it was too high, particularly
12 TT-23. It was not a good match at that location,
13 but in, you know, it's a model. You know,
14 calibration yields some, you know, it's a best
15 fit. Best fit by definition means at some point
16 it's too high. At some points it's too low.

17 In this case, you know, for the
18 Tarawa Terrace model, I think, you know, that's
19 certainly true. In some places, it's too high.
20 In some places, it's too low. It may be a little
21 too high at more places than you'd like. So there
22 is a slight, but I think it's not. I think
23 Spiliotopoulos overstated the degree to which it
24 overestimates.

1 Q. Turning back to -- I forget --
2 Exhibit 16, which is the transcript I handed you.
3 This is day 2 of the transcript -- excuse me.

4 This is the transcript for day 2 of
5 the 2009 expert panel.

6 A. Yes.

7 Q. Do you see that?

8 A. Yes.

9 Q. Okay. It's dated April 30, 2009;
10 correct?

11 A. Yes.

12 Q. Okay. If you turn to page 216 in
13 the transcript.

14 A. 2-1-6?

15 Q. Correct.

16 Are you there?

17 A. Yes.

18 Q. Okay. Your name is highlighted
19 there in the middle starting on line 5.

20 A. Yes.

21 Q. It states:

22 "You kind of mentioned earlier that
23 you have quite a lot of variability over short
24 periods of time in the observed concentration."

1 Which is what I think you were just
2 talking about?

3 A. Yes.

4 Q. And the next line is:

5 "That's really going to be a big
6 obstacle to calibrating the model."

7 Did I read that correctly?

8 A. That's what I said at the time.

9 Q. Okay. And those are your words;
10 correct?

11 A. Apparently.

12 Q. And Mr. Faye responds:

13 "It was and it is."

14 And you respond:

15 "Look at Figure F-16" the one we
16 just discussed in your report. You say:

17 "Look at Figure F-16 in your Tarawa
18 Terrace report. You have this simulated curve
19 that's coming up, a nice smooth curve, and then
20 there's one point in, I guess, 1985, where you
21 have five frequently, sampled -- you have five
22 frequently, samples collected over a short period
23 of time."

24 And then you go on to say:

1 "And they have a range much greater
2 than the long period of the --"

3 And then Mr. Faye cuts you off:

4 "I know. I know, Lenny. Let me
5 make a comment on that. In part -- in part of my
6 comment I'll reference, for example, the Table
7 C-7, if you want to check that out."

8 And then he goes on to explain a lot
9 the reasons for variability of concentration data.

10 I just wanted to confirm it.

11 As -- as of the 2009 expert panel,
12 it was your belief that the figure that we were
13 looking at demonstrated that calibrating the model
14 was going to -- it was going to be a big obstacle
15 to calibrate the model; right?

16 MR. DEAN: Objection to the
17 form.

18 Read the next few pages of the
19 transcript for him in context, not just a
20 section on it.

21 MS. BAUGHMAN: You can read as
22 much of it as you want before you answer.

23 BY MR. ANWAR:

24 Q. Well, let me ask this.

1 A. Okay.

2 Q. On page 216, the quote from lines 5
3 to 9, those are your words; right?

4 A. Yes.

5 Q. Okay. That's -- we can move on from
6 that.

7 A. I assume I was talking about the
8 Hadnot Point/Holcomb Boulevard model there.

9 Q. Why do you assume you were talking
10 about the --

11 A. Because this was an expert panel on
12 the Hadnot Point/Holcomb Boulevard model.

13 Q. Why would you immediately then refer
14 to F16?

15 A. By "immediate," I'm not sure what
16 you mean by immediately, but this is page 216 on
17 the second day. So it wasn't immediate.

18 Q. No. I guess I mean: You make the
19 comment about being a big obstacle to calibrating
20 the model. Mr. Faye responds "It was and it is"
21 and then you say "Look at F-16 in your Tarawa
22 Terrace report."

23 A. That refers to Tarawa Terrace.

24 Q. Okay.

1 A. I can't -- I can't say that the
2 previous comment was about Tarawa Terrace.

3 Q. Okay. So the -- the obstacle to
4 calibrating the model was at Hadnot Point/Holcomb
5 Boulevard?

6 A. I --

7 MR. DEAN: Object to the form.

8 THE WITNESS: I'm not sure,
9 but that's -- without reading back, I
10 think that's what we were talking about,
11 but I'm not positive.

12 BY MR. ANWAR:

13 Q. Okay. Fair enough.

14 MS. BAUGHMAN: Just for the
15 record, he didn't have time to read the
16 pages before and after for context.

17 MR. ANWAR: The record may
18 reflect that.

19 I'm going to hand you what I'm
20 marking as Exhibit 17.

21 (Document marked for
22 identification as Konikow Exhibit 17.)

23 THE WITNESS: Thank you.

24 BY MR. ANWAR:

1 Q. Exhibit 17 is a copy of Chapter F
2 for the Tarawa Terrace model; correct?

3 A. Yes.

4 Q. And so I wanted you to turn to page
5 33. It's page F33, and on page F33 there's a
6 figure, Figure F12; correct?

7 A. Yes.

8 Q. And Figure F12 is comparing observed
9 PCE concentration versus simulated PCE
10 concentration for the Tarawa Terrace model;
11 correct?

12 A. Yes.

13 Q. And would you agree that Figure F12
14 shows the model to be overpredicting PCE
15 concentrations?

16 MR. DEAN: Object to form.

17 THE WITNESS: I would agree
18 that there are more data points above the
19 solid line than below it, but what I
20 would note is that at the real critical
21 important high concentrations, the fit is
22 very good.

23 I would also note that there
24 are many or at least several duplicative

1 samples in here that really present a
2 little bit of an unfair picture in that
3 they're, you know, they reflect samples
4 collected within a day or two at the same
5 location and, therefore, shouldn't be
6 plotted in a way that seems to give equal
7 weight to each value.

8 BY MR. ANWAR:

9 Q. If you --

10 A. I think I discuss that in my expert
11 report.

12 Q. But you would agree that F12
13 demonstrates that the model overpredicts. TT
14 model is overpredicting; correct?

15 MR. DEAN: Object to form.

16 Asked and answered.

17 THE WITNESS: It's a limited
18 number of points. There are some points
19 there that probably shouldn't be there.
20 It doesn't include the agreement at
21 locations or for data points where there
22 were non-detects reported.

23 But in terms of what's shown
24 in Figure 12, there are more data points

1 above, but that's not -- this is just for
2 a limited number of observation points.
3 It's not a reflection of the
4 reasonableness of the whole model.

5 BY MR. ANWAR:

6 Q. Would you agree that calibration
7 targets are subjective?

8 A. Targets?

9 Q. Yeah.

10 A. I would say so.

11 Q. And then, therefore, whether a model
12 is calibrated is a subjective assessment as well?

13 A. Partly subjective. I mean, as a
14 hydrogeologist, you would have a good sense as to
15 whether or not you have a reasonable calibration,
16 but that assessment is certainly at least in part
17 subjective.

18 Q. What does the location of the
19 observed concentrations relative to the line in
20 Figure 12 tell you about the calibration and the
21 fit of observed versus simulated concentrations?

22 A. Tells me at the high concentrations,
23 the model did a really good job. Knowing some of
24 the basis of some of the data, I think some of the

1 points probably should be lumped together and not
2 shown as separate independent points. They're not
3 independent samples.

4 It's a very -- relative to the
5 number of calculations done in the model, this is
6 an extremely, extremely small sample. But that's
7 part of the problem that there just aren't that
8 many observed concentrations certainly over time.

9 But yeah, I -- yeah, I mean, this
10 table shows more values above that line of a
11 perfect match than below it.

12 Q. And there in the text right above
13 the last paragraph on F33, it says:

14 "Both results indicate that
15 simulated PCE concentrations moderately to
16 substantially overpredicted observed
17 concentrations at water-supply wells."

18 Correct?

19 A. That's what it says.

20 Q. Okay. So ATSDR in its report
21 indicated that the PCE concentrations were
22 moderately to substantially overpredicted, right,
23 at the water supply wells?

24 A. Well, what they said what you read

1 there. I would argue that they themselves gave
2 equal weight to those points, and I argue in my
3 expert report I point out that they should really
4 consider the overall accuracy at each of the
5 observation wells, which gives you a different
6 picture. Not a perfect picture, but it gives you
7 a different picture of the nature of the
8 overprediction and the calibration.

9 And in my expert -- expert report, I
10 think pointed out at 73 percent of the locations,
11 the fit was within their calibration targets as
12 opposed to the image given by in the report itself
13 and as pointed out by Dr. Spiliotopoulos.

14 Q. Did you say 73 percent fell within
15 the calibration standard?

16 A. In terms of the location, the
17 individual wells. I can look in the report and
18 see exactly what I said, but I think that's what I
19 said.

20 Q. Okay. It's okay.

21 A. Yeah.

22 Q. We can -- we can come back to that.
23 Would you agree that groundwater
24 data gets more independent the further apart the

1 data sets are in time?

2 MR. DEAN: Object to form.

3 THE WITNESS: I'm not sure I
4 understand the question.

5 BY MR. ANWAR:

6 Q. Okay. Scratch that. We'll come
7 back to that.

8 I guess the reference to that -- so
9 let me -- let me backtrack to that -- that last
10 question quickly.

11 I think you said -- and you correct
12 me if I'm wrong -- that data points are -- the
13 data points for -- it was F16 that we were looking
14 at -- were not independent because they were too
15 close in time; correct?

16 A. I don't remember if I said that they
17 weren't independent. I said, you know, in
18 Figure -- F-16 we're talking about?

19 Q. Correct.

20 A. I said they're close in time and
21 they have a very large spread or a large variance
22 in the values. The individual. The five values
23 that are collected at this scale it looks like
24 within a few days or so of each other show a large

1 range in concentration from close to 1600 to, you
2 know, 10 or 20 or 30, very low value.

3 And that's a degree of change that I
4 would not have expected in such a short period of
5 time in the same location, and yet there it is.
6 So I don't doubt that it happened. It's certainly
7 been observed in other areas where you get such a
8 big change in concentration.

9 So I don't understand the reference
10 to independence, but each of those five samples
11 were collected at the same location at slightly
12 different times and they showed widely varying
13 values.

14 MR. ANWAR: Okay. I'm going
15 to hand you what is being marked as
16 Exhibit 18.

17 (Document marked for
18 identification as Konikow Exhibit 18.)

19 BY MR. ANWAR:

20 Q. This is an article that you
21 published in "Groundwater" in 1986; right?

22 A. Yes.

23 Q. It's entitled "Predictive Accuracy
24 of a Ground-Water Model - Lessons from a

1 Postaudit"?

2 A. Yes.

3 Q. I just had a couple questions about
4 this article.

5 A. Okay.

6 Q. If you could turn to page 178.

7 A. 178?

8 Q. Correct.

9 A. Okay.

10 Q. There is Figure 8 there.

11 A. Yes.

12 Q. And you describe it as:

13 "Relation between predicted and
14 observed changes in water level in the
15 Tempe-Mesa-Chandler area of the Salt River basin,
16 Arizona, 1964 to '74. Solid line shows where
17 predicted equals observed values."

18 Did I read that correctly?

19 A. Yes.

20 Q. Okay. And it's very similar to --
21 understandably different site, different model,
22 but the presentation itself is very similar to the
23 figures we just looked at for -- for Tarawa
24 Terrace; correct?

1 MR. DEAN: Objection to form.

2 THE WITNESS: In a certain
3 sense, yeah.

4 BY MR. ANWAR:

5 Q. It's comparing observed versus
6 predicted --

7 A. Yeah.

8 Q. -- values?

9 A. Yeah.

10 Q. And so if you -- underneath there,
11 there is text under Assessment and Prediction.
12 Second paragraph states:

13 "The relationship between the
14 predicted and observed changes in water levels is
15 illustrated in Figure 8. If the predictions were
16 relatively accurate, the data should plot along
17 (or close to) the 45 degree line connecting equal
18 values of predicted and observed changes.
19 Instead, data from all but three wells fall below
20 that line, indicating poor accuracy and the
21 presence of bias in the model predictions."

22 Did I read that correctly?

23 A. Yes.

24 Q. And in this article, you stated that

1 the model indicated poor accuracy due to the fit
2 of the simulated concentrations, the observed
3 versus simulated on the line; is that right?

4 A. Can you say that again?

5 Q. Sure.

6 In this article, you said because
7 the simulated or predicted values fell below the
8 45 degree line --

9 A. Yes.

10 Q. -- that it indicated poor accuracy
11 and presence of bias in the model predictions;
12 correct?

13 A. Yes.

14 Q. And why is that?

15 A. The scatter was very large and the
16 magnitude of the errors of the differences was
17 very large. Much larger than in the example from
18 Tarawa Terrace.

19 Here you have where the observed
20 water level -- let's see -- some of the points
21 where it's observed at zero change, they observed
22 a drawdown or a negative change of more than 160
23 feet.

24 And errors in the groundwater flow

1 model, you know, more than 50 feet to 100 feet is
2 really large, and here there were quite a few that
3 were really very large in terms of the magnitude
4 of the error. But, you know, clearly, you know,
5 this would reflect a bias.

6 Q. Okay. Those -- those are the
7 questions I have about that document.

8 Let's take a quick two-minute break.
9 Thank you.

10 A. Sure.

11 THE VIDEOGRAPHER: We're going
12 off the record. The time is 4:54.

13 (A recess was taken.)

14 THE VIDEOGRAPHER: We're back
15 on the record. The time is 5:01 PM.

16 BY MR. ANWAR:

17 Q. We're back on the record from a
18 short break.

19 Dr. Konikow, are you okay to
20 continue?

21 A. Yes.

22 Q. Okay. I wanted to ask you a couple
23 questions about -- about each of the two models.

24 So for Tarawa Terrace, ATSDR used a

1 simple mixing flow-weighted average model to
2 compute PCE concentrations delivered to the Tarawa
3 Terrace Water Treatment Plant; right?

4 A. Yes.

5 Q. And that was from all active supply
6 wells and subsequently to the Tarawa Terrace water
7 supply network.

8 Does that sound right to you?

9 A. That sounds right, yes.

10 Q. Okay. And they did the same thing
11 for Hadnot Point, correct, used a simple mixing
12 model?

13 A. I believe that's what they did.

14 Q. And so you'd agree that ATSDR didn't
15 model -- or strike that. Let me ask.

16 You'd agree that neither the Tarawa
17 Terrace nor the Hadnot Point/Holcomb Boulevard
18 models included calculations for contaminant
19 losses during storage treatment or distribution;
20 right?

21 A. I believe so.

22 Q. Meaning you'd agree?

23 A. Yes.

24 Q. Okay. So the models don't take

1 into -- neither Tarawa Terrace model nor the
2 Hadnot Point/Holcomb Boulevard model take into
3 account VOC losses during the water distribution
4 process; correct?

5 A. My recollection of the expert peer
6 panels is that there were experts there in
7 volatilization and water treatment processes, and
8 they stated, as best I could recollect, that there
9 was not significant volatilization or losses of
10 the VOCs for these particular water treatment
11 plants. And so seemed to me as an expert reviewer
12 of the work that that seemed like a reasonable
13 assumption.

14 Q. So -- so the models don't take into
15 account VOC losses; correct?

16 A. The inference was that there are no
17 VOC losses to account for.

18 Q. So they don't take into account
19 losses that they don't account for; correct?

20 MR. DEAN: Object to the form.

21 THE WITNESS: They don't take
22 into account losses that don't exist.

23 BY MR. ANWAR:

24 Q. Okay. I think earlier you mentioned

1 reviewing Sabatini's rebuttal report; correct?

2 A. Let's say I read it. I, you know,
3 in the sense reviewing it in the sense of having
4 read it, but it was not a technical review of
5 Sabatini's report.

6 Q. And Dr. Sabatini acknowledges that
7 VOC losses do occur in the water distribution
8 process; right?

9 A. Very small. You know, he was
10 talking about maybe, as I recall, maybe a 6
11 percent loss, but it was -- he implied that this
12 was pretty negligible, as I recall.

13 Q. And you would agree whether it's 6
14 percent, or some other number, the ATSDR models
15 don't take into account those losses; correct?

16 A. The groundwater flow and solute
17 transport models that I reviewed did not include
18 the Water Treatment Plant. So what was done to
19 the water distribution model I did not look
20 closely at, but I know that they did not include a
21 volatilization loss in that model.

22 You know, the data from the Water
23 Treatment Plant, in effect, they were computing
24 what it was, but that didn't go into the model

1 calibration. It really was a -- I mean, what they
2 ended up doing in the end is increasing the
3 confidence in the groundwater flow and transport
4 models because there was a pretty good match
5 between their estimated concentrations in the
6 Water Treatment Plant and what was actually
7 observed there. So, but that was without
8 considering volatilization.

9 Q. Okay. Thank you.

10 I wanted to talk to you a little bit
11 about the retardation factor. You addressed that?

12 A. Yeah.

13 Q. You addressed some of
14 Dr. Spiliotopoulos's -- Spiliotopoulos's -- it's
15 been a long day --

16 A. Yeah.

17 Q. -- opinions --

18 A. Yes.

19 Q. -- about the retardation factor and
20 the variables in calculating the retardation
21 factor; correct?

22 A. Yes.

23 Q. Okay. Can you explain to me what a
24 retardation factor is?

1 A. Okay. The retardation factor
2 reflects that some constituents, like PCE, are
3 somewhat reactive with the solid grains of the
4 aquifer, and they would tend to sorb or ion
5 exchange onto the solid grains.

6 This means as a net, the net average
7 velocity -- because of sorption and desorption
8 reaction going on, the net velocity of that
9 constituent can be slower than the net average
10 velocity of the water itself.

11 So you could constituent, you know,
12 it's moving in with the groundwater due to
13 advection. It's spreading a little due to
14 dispersion. But at the same time, some of it gets
15 sorbed and some keeps moving. And then that sorb
16 thing may come off again, desorb and then start
17 moving.

18 And the net effect of all the
19 sorption, desorption, ion exchange, all the other
20 things going on, reactions or the complex
21 reactions, the net effect is assume that you can
22 on the average represent it with a retardation
23 factor that really represents the ratio of the
24 average velocity of the constituent to the average

1 velocity of the water. So that if a retardation
2 factor is 3, the constituent moves at one-third
3 the velocity of the water.

4 Q. Okay. Would it be fair to say the
5 higher -- and you should correct me if I'm
6 misunderstanding this -- but the higher the
7 retardation factor, the longer it takes for the
8 contaminant to travel through the water or the
9 subsurface in the water?

10 A. I think that's fair.

11 Q. Okay. And the same sort of
12 relationship exists between bulk density, which is
13 a variable of the retardation factor; correct?

14 A. I'm not sure I understand the
15 question.

16 MR. DEAN: Object to form.

17 BY MR. ANWAR:

18 Q. Sure.

19 So bulk density is a variable of the
20 calculation for the retardation factor; correct?

21 MR. DEAN: Object to form.

22 THE WITNESS: It's one of the
23 factors that go into estimating the
24 retardation factor if you want to

1 calculate it based on other factors. I
2 mean, it really comes down to the fact
3 that the retardation factor is a
4 component of the transport equation.

5 The bulk density, the KD, and
6 the other terms in there are not directly
7 in the governing equation. They're not
8 in the model.

9 The model kind of externally,
10 you know, it asks for input of KD and
11 bulk density, and then it calculates the
12 retardation factor, and then the solution
13 of the transport equation is based on the
14 retardation factor.

15 So the, you know, the bottom
16 line is that, you know, the parameter to
17 be calibrated on, the parameter to be
18 estimated really is the retardation
19 factor, not -- not individual estimates
20 of bulk density or KD.

21 BY MR. ANWAR:

22 Q. I guess what I was getting at is:
23 If the bulk density increases, doesn't the
24 retardation factor necessarily increase as well,

1 assuming the other variables remain constant, KD
2 and --

3 A. Well, sure, but you can't assume
4 that. You know, again, it's -- the parameter that
5 counts is RF. So, you know, for the calibrated
6 model, if you want to say the bulk density is
7 higher, you have to say the KD is lower in a
8 compensating way.

9 Q. Okay. Dr. Spiliotopoulos pointed
10 out to two errors in ATSDR's Tarawa Terrace model
11 in calculating the retardation factor; correct?

12 A. He pointed out an error in
13 estimating the bulk density using a wet bulk
14 density instead of a dry. That, and I think they
15 acknowledged. They agreed that that was an error.

16 Q. And didn't he point out an error in
17 KD as well?

18 A. I don't recall that but that's...

19 Q. So if we go to page 10 of your
20 report.

21 A. Okay.

22 Q. In the middle of the page under the
23 first paragraph of Opinion 3, middle paragraph you
24 talk about the error that Dr. Spiliotopoulos

1 caught relating to bulk density, correct, for bulk
2 density?

3 A. Yes.

4 Q. Okay. I think maybe I'm
5 misremembering.

6 But in any event, the middle of the
7 page a little further down it says:

8 "However, as Dr. Spiliotopoulos
9 himself admits, this significant impact on RF does
10 not actually occur because the calibration process
11 compensates for an overestimate of PB by
12 estimating a value for KD that appears to be too
13 low. Recall that neither of these two parameters
14 are used directly in the transfer model."

15 Did I read that correctly?

16 A. Yes.

17 Q. And so I think what -- if I'm
18 understanding you, you acknowledge that the bulk
19 density was overestimated; correct?

20 A. And I'm also saying it didn't make
21 any difference.

22 Q. I understand that.

23 But you agree that the bulk density
24 was overestimated; correct?

1 A. Yes, for the Tarawa Terrace.

2 Q. And you agree that the KD was too
3 low; correct?

4 A. Well, in the sense that the model
5 was calibrated to RF, and so if row B was too
6 high, then KD had to be too low. This is the
7 whole concept of compensating errors. That's the
8 essence of a model calibration.

9 Q. But the errors exist is my point;
10 correct?

11 A. Yes.

12 Q. And I understand that it's your
13 opinion that they offset each other, so it's not
14 an issue; correct?

15 A. Well, I think it's -- yeah, it's my
16 opinion. It would also be the opinion of others.

17 Q. Now, the values used for -- the
18 parameter values used for the retardation factor
19 calculation -- and I think you acknowledge this in
20 your report. I can find the precise place if I
21 need to.

22 But the values -- the parameter
23 values used to calculate the retardation factor
24 differ between the Tarawa Terrace model and the

1 Hadnot Point/Holcomb Boulevard model; correct?

2 A. I believe there was a small
3 difference. Yeah. I think one was 2.9 and the
4 other is 3.3 or something on that order. A small
5 difference but, yeah, a difference.

6 Q. And that's even though Tarawa
7 Terrace and Hadnot Point were both on Camp
8 Lejeune; correct?

9 A. Nothing wrong with that. That's a
10 small difference. If you look at the hydraulic
11 conductivity maps, you see much bigger differences
12 over much shorter distances. This is not
13 unexpected in a geologic environment or geologic
14 framework.

15 Q. And I can pull out the report if you
16 need me to show it to you, but ATSDR states in its
17 report in the Hadnot Point/Holcomb Boulevard study
18 that -- excuse me -- it states in -- yeah, in the
19 Hadnot Point report, Holcomb Boulevard report that
20 sorption in the Hadnot Point/Holcomb Boulevard
21 study area is assumed to be similar to sorption in
22 the study area of -- for Tarawa Terrace.

23 A. In terms of the process?

24 Q. Okay.

1 A. Yeah.

2 MS. BAUGHMAN: Object to
3 the -- you didn't show him the document,
4 right? You need to show him the document
5 before he answers that.

6 THE WITNESS: So I think -- I
7 mean, it sounds to me like you're saying
8 they're saying sorption process is
9 sorption process in both areas.

10 BY MR. ANWAR:

11 Q. Okay. And wouldn't that dictate
12 that the parameter values for -- wouldn't that
13 suggest that the parameter values between Tarawa
14 Terrace and Hadnot Point/Holcomb -- and Holcomb
15 Boulevard should -- should --

16 A. Be the same?

17 Q. -- be similar, the same?

18 A. Well, they are similar, but they're
19 not the same, and it does not imply that they
20 would be identical.

21 Q. Okay.

22 A. Or necessarily close. I mean,
23 again, if you look at the hydraulic conductivity
24 map, for which there are a fair number of aquifer

1 tests and slug tests and so on, you find much
2 better. You see a much bigger variability between
3 Tarawa Terrace and Hadnot Point in terms of the
4 precise estimates of hydraulic conductivity.
5 Another important parameter.

6 MR. ANWAR: Okay. I'm going
7 to hand you what I'm marking as
8 Exhibit 19.

9 (Document marked for
10 identification as Konikow Exhibit 19.)

11 BY MR. ANWAR:

12 Q. This is one of the documents that
13 was produced to us last night that was in your
14 possession --

15 A. Yeah.

16 Q. -- Dr. Konikow; is that right?

17 A. That's correct.

18 Q. Okay. And it is a letter to you
19 from Morris Maslia on behalf of ATSDR providing
20 Mr. Maslia or I guess -- yeah -- ATSDR's responses
21 to your review comments; correct?

22 A. It's Bob Faye's responses.

23 Q. Bob Faye's responses. Okay. Thank
24 you.

1 And I think earlier you had
2 indicated that -- we had a discussion about the
3 issues you raised with respect to limited data for
4 both the models that ATSDR performed and other
5 concerns that were raised, and I think you said
6 that you reviewed the reports recently and those
7 issues had been addressed; correct?

8 A. The issues had been addressed, and I
9 think some of the details of those are expressed
10 by Bob Faye in this response letter.

11 Q. Now, in this response letter, Bob
12 Faye, on behalf of ATSDR, doesn't agree with all
13 of the concerns that were expressed; correct?

14 A. That's correct. That's normal.

15 Q. And so is it your testimony that
16 this response or this response along with your
17 recent review of the ATSDR reports is what
18 satisfies your -- your belief that the -- your
19 concerns were addressed?

20 A. Yeah, I think they -- I think they
21 seriously considered every comment and suggestion
22 that I had made and that the expert panel had
23 made, but that doesn't mean they have to accept
24 every one. It's just that I think they did

1 seriously consider every one of them.

2 And, again, you know, they're the
3 ones who worked for years on the site. I only
4 looked at it for a few hours.

5 Q. The major concerns that are listed
6 here, are these the major concerns you raised?

7 A. This is an outcome of my review of
8 the Chapter F draft report. So yeah, these are
9 issues that I raised, I believe.

10 Q. And number 1 there is:

11 "The lumping of two aquifers and one
12 confining unit into the superficial model
13 layer 1."

14 Correct?

15 A. Correct.

16 Q. What was your concern? What was the
17 concern you raised there?

18 A. Well, I was concerned that -- I
19 mean, it's always -- in developing a model,
20 there's always a conflict between lumping and
21 dividing in a general sense, you know. How much
22 do you want to lump? How much do you want to
23 divide?

24 My concern was that if there was a

1 continuous low permeability confining layer lumped
2 in the middle of a single model layer, it might
3 not adequately reflect the vertical velocities
4 through the system.

5 The responses were, I think,
6 alleviated my concerns, pointing out that the
7 material above the confining layer was generally
8 typically for most of the time unsaturated and
9 really would not be included in the model, and if
10 it had been, would have generated numerical
11 difficulties.

12 They pointed out that the confining
13 layer is discontinuous, that it's sandy, and that
14 material would -- there was good hydraulic
15 connection through that layer.

16 And considering everything, I
17 thought, okay, that's a reasonable explanation.

18 Q. Okay. Is there any part of Robert
19 Faye's response to your concern number 1, major
20 concern number 1 that you disagree with?

21 A. (Reviews document.)

22 No. It's an explanation of things
23 that I hadn't fully appreciated at the time I did
24 the review.

1 Q. Number 2 of your major concerns:
2 "The use of a finite-difference
3 method to solve the governing transport equation
4 (which causes substantial numerical dispersion,
5 especially if time steps are too large)."

6 What was your concern there?

7 A. My concern was that just the
8 finite-difference numerical solution itself can
9 cause calculated concentrations to increase, to
10 spread where it's not related to the physical
11 process of dispersion, and that was my concern.
12 That's a recognized issue sometimes with the
13 finite-difference numerical method for solving the
14 transport equation.

15 So that was a concern. I think it
16 was a reasonable concern to make sure that they
17 had considered this, evaluated it, and that it
18 wasn't a significant issue.

19 Q. Did this response satisfy you?

20 A. Yes. The response, I mean, I think
21 it pointed out that they did carefully consider
22 the Peclet number and the Courant number and that
23 they did testing for grid spacing and time
24 stepping.

1 Some of this is shown on page 16
2 where they compared calculations at two wells at
3 three different times for using a one day time
4 step compared with their one month time step that
5 was actually used in the model, and it's an
6 incredibly small difference.

7 So that is telling me that this is
8 not a problem. It's not an issue. I mean, the
9 differences are in the, you know, 4th significant
10 figure, which is just --

11 Q. The first --

12 A. -- not one to be concerned with.

13 Q. The first sentence of the response
14 to number 2 about the finite -- finite-difference
15 method is:

16 "First of all the reviewer probably
17 has no idea whether or not using a code based on
18 finite-difference methods caused substantial --
19 'substantial' or insubstantial numerical
20 dispersion during solution of the Tarawa Terrace
21 fate and transport model."

22 Would you agree that you had no idea
23 whether or not using a code based on
24 finite-difference methods caused "substantial" or

1 insubstantial numerical dispersion during solution
2 of the Tarawa Terrace fate and transport model?

3 A. For the case of the Tarawa Terrace
4 model, I did not know whether or not it caused
5 substantial numerical dispersion, which is why I
6 was -- and I suspected he didn't know either, and
7 this is why I brought the issue up.

8 Because in the literature, the issue
9 of numerical dispersion related to
10 finite-difference solutions is in the literature,
11 and that it can under certain circumstances cause
12 substantial numerical dispersion.

13 By "substantial" I'm not sure
14 exactly what that means, but it can cause
15 numerical dispersion due to the solving of the
16 equation rather than due to the physical
17 processes. This is a recognized issue in solute
18 transport modeling and solving the equation.

19 As a reviewer, I felt he had
20 to -- because they were using the
21 finite-difference method, I felt he had to address
22 it more carefully than he had.

23 Q. Okay. Number 3 on the next page,
24 page 4 states:

1 "The reliability of the estimate of
2 the biodegradation rate constant based on the
3 assumption that concentration declines observed at
4 one location over a period of several years can be
5 explained solely by biodegradation."

6 What was your concern there?

7 A. I don't remember all the details of
8 that concern, but I think the way they estimated
9 biodegradation rates. I'm not positive. I think
10 they looked at some condition where the
11 concentration decreased over time, and they used
12 that as a basis for estimating the degradation
13 rate.

14 And I was raising a concern that how
15 well could they isolate the degradation due to
16 biodegradation versus a reduction in concentration
17 due to advection and dispersion, and, you know, I
18 don't remember in detail what -- how they actually
19 did that calculation. I just don't remember.

20 Q. And the first line of the response
21 there on number 3 is:

22 "The authors never claimed that the
23 biodegradation rate computed using field data was
24 reliable or the sole reason for the observed

1 decline in PCE concentration."

2 Did I read that correctly?

3 A. Yes.

4 Q. So is Robert Faye saying here that
5 the biodegradation rate computed using field data
6 wasn't reliable?

7 MR. DEAN: Object to form.

8 THE WITNESS: What I think the
9 implication is, the bottom line is that
10 he's saying that it's a parameter that
11 had to be estimated with the calibration
12 process. It's a parameter, just like the
13 retardation factor.

14 It's a parameter that you
15 couldn't rely completely on the
16 calculation. You had to use it as a
17 parameter in the calibration method.

18 It's a parameter that had to
19 be estimated just like the retardation
20 factor, and you adjust the values of
21 these within some reasonable range to
22 yield the best fit for the overall
23 simulation.

24 And I think what he's saying

1 here is that he recognizes that this is a
2 parameter to be adjusted during the
3 calibration.

4 BY MR. ANWAR:

5 Q. To your knowledge, did ATSDR test
6 higher biodegradation rates for TT, for Tarawa
7 Terrace?

8 A. I believe they did.

9 Q. Did you evaluate the range of
10 biodegradation rates that ATSDR considered?

11 A. I -- I'm sure I looked at it, but I
12 didn't do a detailed evaluation of it. I'm pretty
13 sure I did not, but I think certainly at the time
14 I did the review, I was aware of what they did.

15 Q. Do you recall the biodegradation
16 rate that they ended up using for Tarawa Terrace?

17 A. Yeah. Yeah. I mean, here they're
18 talking about .0005 in that range, and so I assume
19 they went up and down from 0005 to a higher value
20 and a lower value. I don't recall exactly what
21 the range was.

22 Q. Number 4 on page 4 states:

23 "The exclusion of concentration data
24 collected in monitoring wells from the calibration

1 basis."

2 Why was it a major concern to you to
3 exclude concentration data collected in monitoring
4 wells for calibration?

5 A. I'm not sure if it was a major
6 concern compared with some other things. It was a
7 concern, and I didn't understand why if they had
8 concentration data from a monitoring well or from
9 a point, why they would not use that in the
10 calibration.

11 I'm -- I'm, you know, he gave an
12 answer, but I'm still not sure why. If I was
13 doing it, I probably would have used those values,
14 with the recognition that it's a sample from a
15 point rather than a pumping well that brings in
16 lots of water.

17 So I think that was kind of his
18 basis for not using it is that it was sampling an
19 extremely small volume of the aquifer.

20 I would have, you know, I, you know,
21 if I was doing it, I would say, well, it's still a
22 point within the volume and I would have -- I
23 would have looked at it and, you know, I might --
24 unless I saw some reason not to, I would have used

1 it in the calibration.

2 But he had a reason for not and, you
3 know, we may disagree on that.

4 Q. Okay. So that may be at least one
5 area where you disagree in terms of these
6 comments?

7 A. Well, to some extent. You know,
8 it's certainly not a fatal flaw in the
9 calibration. It's a -- it's his way of looking at
10 it and I, you know, he had experience in the area.
11 He worked it for years.

12 I only, you know, spent two days
13 reviewing it. So, you know, that's -- I didn't
14 have the hands-on experience he did, but -- but
15 from what I, you know, I probably would have used
16 the monitoring well data as part of the
17 calibration.

18 Q. Okay. The number 5 there on page 5
19 identifies as a concern that you had:

20 "The use of a much larger mass
21 loading rate than apparently was indicated by the
22 field data in order to improve model calibration."

23 Tell me about that concern.

24 A. I don't remember the details of why

1 I said that. I can't remember.

2 Except that there must -- there
3 probably was some indication or initial estimate
4 of what the mass loading rate was, and it was
5 adjusted in the model calibration to achieve the
6 best fit, and that calibration indicated a much
7 higher mass loading rate.

8 And, you know, it's -- it's an
9 issue, again, I don't recall the details of.

10 Q. So Robert Faye in his response
11 starts by saying:

12 "First of all please note that field
13 data did not indicate a mass loading rate. The
14 computations of PCE mass in the saturated and
15 unsaturated zones described in the report were the
16 result of a highly interpretative, somewhat
17 subjective calculation using field data."

18 Do you see that there?

19 A. Yes.

20 Q. What is -- what was your reaction to
21 that response to the concern you had expressed?

22 A. You know, I don't remember my
23 reaction at the time but, you know, you're looking
24 at it now. He's explaining what he did, maybe a

1 little more clearly than was in the report.

2 You know, he's saying that there's
3 some subjectivity and approximations that went
4 into that calculation, which itself is not
5 surprising considering the nature of the sources.

6 Q. Did you disagree at all with the
7 mass loading rate ATSDR chose to use?

8 A. Not per se, no. No.

9 Q. Do you disagree with the start date
10 for contamination that ATSDR chose to use for
11 Tarawa Terrace?

12 A. No, it seemed reasonable.

13 Q. Between the Tarawa Terrace model and
14 the Hadnot Point and Holcomb Boulevard model, do
15 you view one model as better or more accurate than
16 the other?

17 MR. DEAN: Object to form.

18 THE WITNESS: Both models, I
19 think, are reasonable, using well
20 accepted state-of-the-art methods. I
21 think both models are quite acceptable.
22 I think their predictions are reasonable,
23 with the recognition of uncertainty.

24 The Tarawa Terrace model

1 clearly had a better defined source term
2 and that, you know, probably yields a
3 little more confidence in that model. A
4 little more confidence in the results.

5 But the numerical solutions I
6 think are good numerical solutions in
7 both cases given the assumptions about
8 the stresses on the system and the
9 parameters.

10 I mean, they're basically the
11 same model in the sense that they're both
12 using MODFLOW and MT3D, which are both
13 good models.

14 BY MR. ANWAR:

15 Q. The Hadnot Point/Holcomb Boulevard
16 site was more complex to model than Tarawa
17 Terrace; right?

18 A. In the sense of source terms and
19 mass loading, yes. Other than that, I think
20 they're equivalent.

21 Q. There were more sources at Hadnot
22 Point; correct?

23 A. Yes. Yes.

24 Q. There were -- were there more wells

1 to examine in Hadnot Point/Holcomb Boulevard?

2 A. Probably a few more. I think
3 -- yeah, I think there were more. I don't recall
4 the numbers, though, but...

5 Q. Was Hadnot Point/Holcomb Boulevard a
6 generally larger area to model?

7 A. It was somewhat larger, yeah, and
8 also they -- for the transport, they broke it down
9 into two separate MT3D models. One focusing on
10 the landfill area and another focusing on the
11 industrial area. So there wasn't one MT3D model
12 for the Hadnot Point/Holcomb Boulevard. There's
13 one flow model.

14 Q. The Holcomb Boulevard/Hadnot Point
15 model also included a water distribution model to
16 simulate connections between Hadnot Point and
17 Holcomb Boulevard; right?

18 A. I believe so.

19 Q. And that was an additional
20 complexity introduced into the Hadnot
21 Point/Holcomb Boulevard modeling; correct?

22 A. I guess you could say that. I don't
23 think that was a major complexity, but yeah, it
24 was an additional factor.

1 Q. Could you turn to page 10 of this
2 document.

3 A. Okay.

4 Q. In the middle of the page, so page
5 46 to 49.

6 A. 59?

7 Q. 59. Excuse me. Thank you.

8 It looks like Robert Faye agrees
9 with a suggestion you made, and it says "A
10 sentence has been added to the report."

11 Do you see that?

12 A. Yes.

13 Q. And then underneath that, he
14 discusses biodegradation rate again and he says:

15 "Disagree. This criticism was
16 previously addressed under Major Concerns, item
17 #3," which we just discussed. "The reviewer's
18 suggestion to simulate PCE concentrations using a
19 degradation rate of zero and adjust the field data
20 by simulated changes is not accepted. Adjustments
21 to field data using such simulated changes would
22 not add any additional certainty -- any
23 additional -- would -- excuse me -- adjustments to
24 field data using such simulated changes would add

1 additional uncertainty to an already uncertain
2 process."

3 Do you agree with what he's saying
4 there?

5 A. I think it's a reasonable
6 perspective and so, yeah, I certainly would accept
7 that comment.

8 Q. You had suggested, according to this
9 document, "to simulate PCE concentrations using a
10 degradation rate of zero and adjust the field data
11 by simulated change -- and adjust the field data
12 by simulated changes."

13 What did you mean by that?

14 A. First of all, I don't remember
15 precisely what I suggested. I don't have that
16 original comment in front of me.

17 But just from what it says here, I'm
18 assuming I had suggested whatever biodegradation
19 rate he used, I said rerun it with zero and
20 assess, you know, see what difference is. What --
21 what -- assess at least qualitatively what the
22 impact of that biodegradation is.

23 But I don't recall it precisely or
24 at all exactly what I said there, but it was a

1 suggestion. He didn't. He disagreed, and I think
2 that's fine.

3 Q. Okay. On -- if you skip down a
4 couple of the page 59 comment.

5 A. Yeah.

6 Q. It says "Mass loading" and Robert
7 Faye says:

8 "Disagree. See comments under Major
9 Concerns, item #5. The reviewer seems to assign a
10 high degree of accuracy and credibility to the PCE
11 mass computation that is unwarranted. As
12 explained previously, the computation of PCE mass
13 was a highly interpretative and somewhat
14 subjective -- highly interpretative and somewhat
15 subjective process frequently based on
16 questionable data."

17 Did I read that portion correctly?

18 A. You read it correctly.

19 Q. Do you have any understanding of
20 what means when he says "the computation of PCE
21 mass was a highly interpretative and somewhat
22 subjective process frequently based on
23 questionable data"?

24 MR. DEAN: Object to the form.

1 THE WITNESS: You know,
2 I'm -- right now I'm not sure what he
3 meant. I don't recall at the time if I
4 understood what he meant. I'm just
5 -- I'm just not sure.

6 Except that he's -- he's
7 saying that the computation of PCE mass,
8 there's a lot of uncertainty there seems
9 to be what he's saying, and I certainly
10 don't disagree with that.

11 I don't -- I don't recall
12 assigning a high degree of accuracy to
13 it, but he seems to imply that I did or
14 at least he inferred that I did. I don't
15 think I would have, but I don't know.

16 BY MR. ANWAR:

17 Q. That's what the document states;
18 right?

19 A. Yeah.

20 Q. He goes on to say in the rest of
21 that:

22 "Field data applied to the PCE mass
23 computation were limited both spatially and
24 vertically. The computation was accomplished

1 regardless of data limitations to provide an
2 estimate of a minimum mass loading rate to use to
3 begin model calibration."

4 Is that right?

5 A. Okay. Tell me again which paragraph
6 you're reading. The first paragraph on page 59 or
7 the second one under that? Sorry. I lost track.

8 Q. No, it's okay. It's okay. I think
9 you -- you addressed what I was asking you.

10 MR. ANWAR: Let's take a short
11 break. I think I'm close to wrapped up.
12 I just want to check my notes.

13 THE VIDEOGRAPHER: We're going
14 off the record. The time is 5:43 PM.

15 (A recess was taken.)

16 THE VIDEOGRAPHER: We're back
17 on the record. The time is 5:51 PM.

18 BY MR. ANWAR:

19 Q. Okay. A few more questions for you,
20 Dr. Konikow.

21 A. Okay.

22 Q. I appreciate you're willingness to
23 speak with us. I know it's been a long day.
24 I wanted to ask you.

1 In terms of parameter estimation or
2 determining parameters as inputs in the model,
3 generally speaking, is it better -- is a parameter
4 that reflects the real world better than one that
5 doesn't?

6 A. That seems like a reasonable
7 statement.

8 MR. ANWAR: Okay. Okay. I'm
9 handing you what I'm marking as
10 Exhibit 20.

11 (Document marked for
12 identification as Konikow Exhibit 20.)

13 BY MR. ANWAR:

14 Q. And I will just represent to you
15 that this is ATSDR's response to a critique that
16 the Navy offered about the Tarawa Terrace
17 modeling.

18 Have you seen this before?

19 A. Not that I recall.

20 Q. Okay. Did you review the Navy's
21 critique of the Tarawa Terrace model in forming
22 your -- the opinions in your rebuttal report?

23 A. No, I don't remember seeing this.

24 Q. Okay. If you could turn to

1 page -- I'm going to have to identify it by the
2 Bates ranges. It's the page ending 33271.

3 A. Say that again.

4 Q. So at the bottom, there's a little
5 Bates stamp that says "CLJA_WATERMODELING."

6 A. Yes.

7 Q. And then there's a number. It's the
8 one at the end that says 33271.

9 A. 33271?

10 Q. Correct.

11 It's in the middle of the page,
12 there is a comment from the Navy labeled 7.1.

13 Do you see that?

14 A. Yeah.

15 Q. Okay. And so I just wanted for
16 context to provide you the -- or show you the
17 comment that ATSDR was responding to.

18 The Navy stated:

19 "However, all comparisons did not
20 fall within the calibration range. At the Water
21 Treatment Plant, 12% of the simulated PCE
22 concentrations failed the calibration standard ...
23 at the water supply wells, a majority (53%) of the
24 simulated concentrations fell outside of the

1 outside the calibration standard."

2 Did I read that correctly?

3 A. You read it correctly.

4 Q. Is that consistent with your
5 understanding of the calibration for the Tarawa
6 Terrace model?

7 MR. DEAN: Objection to the
8 form of the question.

9 THE WITNESS: I'm not sure,
10 but I've seen that 53 percent number, I
11 think, in Alex Spiliotopoulos' in his
12 report, and I disagree that that was a
13 fair assessment of the accuracy.

14 BY MR. ANWAR:

15 Q. Okay. If you turn the page, ATSDR
16 responds -- well, ATSDR starts responding on the
17 prior page, but their response goes on to the next
18 page.

19 So on the page ending 33272, I just
20 wanted to ask you about a portion of their
21 response.

22 A. Okay.

23 Q. The very last paragraph there
24 states:

1 "To address the issue of the
2 intended use of the water-modeling results by the
3 current ATSDR epidemiological study, the
4 Department of Navy should be advised that a
5 successful epidemiological study places little
6 emphasis on the actual (absolute) estimate of
7 concentration and, rather, emphasizes the relative
8 level of exposure. That is, exposed individuals
9 are, in effect, ranked by exposure level and
10 maintain their rank order of exposure level
11 regardless of how far off the estimated
12 concentration is to the true -- 'true' (measured)
13 PCE concentration. This rank order of exposure
14 level is preserved regardless of whether the mean
15 or the upper or lower 95% of simulated levels are
16 used to estimate the monthly average contaminant
17 levels. It is not the goal of the ATSDR health
18 study to infer which health effects occur at
19 specific PCE concentrations -- this task is for
20 risk assessment utilizing approaches such as
21 meta-analysis to summarize evidence from several
22 epidemiological studies because a single
23 epidemiological study is generally insufficient to
24 make this determination."

1 And then it goes on:
2 "The goal of the ATSDR
3 epidemiological analysis is to evaluate
4 exposure-response relationships to determine
5 whether the risk for a specific disease increases
6 as the level of the contaminant (either as a
7 categorical variable or continuous variable)
8 increases."

9 Did I read that correctly?

10 A. I think you read it correctly, yeah.

11 Q. What do you understand ATSDR to be
12 saying in this response?

13 MR. DEAN: Object to the form
14 of the question.

15 You want him to comment on
16 what ATSDR is saying, right?

17 MR. ANWAR: Isn't that what
18 he's doing anyway?

19 MR. DEAN: No. Object to
20 form.

21 MR. ANWAR: That's his role as
22 an expert.

23 THE WITNESS: I think what
24 they're saying is that the exposure

1 levels are considered in terms of a
2 ranking based on how -- where it is in
3 the scale and that it's not based on the
4 actual concentration value.

5 So it's like a high, low,
6 medium or, you know, some -- something on
7 that scale rather than 95.3 to 89.9 or
8 anything like that.

9 So but, again, I'm, you know,
10 I'm certainly not an expert in
11 epidemiological studies, so I'm not sure
12 what all the implications here are.

13 BY MR. ANWAR:

14 Q. It appears to me he's saying, for
15 the purpose of a successful epidemiological study,
16 at least the one ATSDR was conducting, and I'm
17 quoting, it says:

18 "Places little emphasis on the
19 actual (absolute) estimate of concentration" and
20 then it goes on to say "regardless of how far off
21 the estimated concentration is to the 'true'
22 (measured) PCE concentration."

23 Based on that, it appears to me he's
24 saying that for this model for the purpose that it

1 was intended for in terms of providing information
2 for epidemiological studies, it doesn't matter
3 what the absolute concentrations levels are
4 produced by the model and it doesn't matter if
5 they're inaccurate.

6 Do you agree with that?

7 MR. DEAN: Object to the form.

8 THE WITNESS: Well, it depends
9 what you mean by "inaccurate" because if
10 you, you know, you still want it accurate
11 in the sense of what's high is high and
12 what's low is low, what's in the middle
13 is in the middle.

14 You know, the actual
15 concentration level we already know has
16 uncertain -- that's computed we know has
17 uncertainty associated with it.

18 So there's, you know, it's
19 naturally going to be imprecise and, you
20 know, you can't say it's going to be 99.5
21 micrograms per liter because it might be
22 higher or lower because of all the
23 uncertainty in the model.

24 But you certainly want

1 consistency in the model. You want the
2 model to, you know, have a good mass
3 balance. You want, you know, the
4 numerical solution should be accurate for
5 the conditions in terms of solving the
6 equation.

7 I think all of those
8 conditions are met.

9 What exactly they mean by a
10 rank order I'm not precisely sure, but I
11 would imply that some -- this is somehow
12 related to exposure levels, but I don't
13 completely understand that.

14 BY MR. ANWAR:

15 Q. Does this response change or inform
16 anything that you've stated today about the -- the
17 accuracy of the model predictions, the simulated
18 contaminant concentrations produced by the ATSDR
19 models?

20 A. No. No. I mean, I'm not evaluating
21 the model from a perspective of the health
22 exposure studies.

23 I'm evaluating it in terms of the
24 solution to the equation for the initial

1 conditions, the boundary conditions, the estimated
2 parameters, and everything related to that.

3 So, you know, the concentrations in
4 the Water Treatment Plant, to the best of my
5 knowledge, were not used for the calibration but
6 served as a way to increase confidence in the
7 model.

8 These were computed by the mixing
9 model that you mentioned a few minutes ago, which
10 was really subsequent to the MT3D modeling.

11 So it's kind of like a next -- I
12 wouldn't call it independent, but it's a -- it's a
13 kind of standalone process that estimated the
14 concentrations in the Water Treatment Plant based
15 on what the computed results of the model.

16 And these were not part of the
17 calibration, to my best recollection, but it
18 certainly served to increase confidence in the
19 model because those, you know, where they did have
20 observed data, it generally looked reasonably good
21 in terms of matching the -- you know, what this
22 mixing model did to estimate the concentrations in
23 many cases agreed closely with what was observed.

24 Q. Okay. As a -- those are the

1 questions I had about this document.

2 As a member of the National Academy
3 of Engineering and as someone that has served on
4 National Research Council committees in the past,
5 were you aware that the National Research Council
6 also issued a report on ATSDR's water modeling
7 efforts?

8 A. I believe it was 2009?

9 Q. Correct.

10 A. Yes, I was aware of that.

11 Q. The report itself addressed sort of
12 epidemiology -- epidemiological and broader
13 issues, but there was a portion focused on --

14 A. Yeah.

15 Q. -- exposure assessment and the water
16 modeling.

17 Were you aware of that?

18 A. I -- I read the charge of the
19 committee, and the charge of the committee really
20 focused on epidemiological studies and health
21 effects. The charge to the committee did not --
22 actually did not mention the groundwater modeling
23 at all, but obviously the groundwater modeling was
24 what led to the estimates. So that was a

1 legitimate domain for their discussions.

2 But, you know, the committee, I
3 looked at the committee membership. You know, I
4 think there were 10 or 11 members. There was only
5 one who had any expertise in groundwater. The
6 rest were medical and health effects and
7 epidemiologist experts because that was the main
8 charge to the committee.

9 Q. Who was the one expert that was the
10 groundwater modeler?

11 A. Professor Clement.

12 Q. Okay. And what are your opinions
13 about -- so let me back up.

14 Are you aware of what the NRC said
15 about ATSDR's water modeling efforts?

16 A. I looked at that report. I don't
17 recall their exact comments.

18 Q. Do you have any opinion about the
19 National Research Council's comments on the ATSDR
20 water modeling efforts?

21 A. I think I had a few comments because
22 Spiliotopoulos made some comments about it. So I
23 think I had some comments in my rebuttal report
24 about it.

1 Q. Do you remember what those comments
2 are?

3 (Mr. Dean no longer present).

4 A. I see that it's not a huge report.
5 I can probably find it pretty quickly.

6 One of my comments was that of all
7 the members of the panel, there was only one who
8 was an expert in groundwater, and that's a really
9 minority on an NRC panel.

16 Then Morris Maslia published a very
17 detailed response that was published in the
18 journal to his comments, and I thought he did an
19 excellent job countering all of the criticisms.

20 And then Dr. Clement had a reply to
21 the responses, in which the first thing he said
22 was that "My analysis should not be considered a
23 review of the ATSDR modeling," which to me
24 countered everything he had said in the first

1 article about what he did say was that the purpose
2 of his article was to generate discussion about
3 model complexity in general and he did not intend
4 to, you know, as a criticism.

5 What he implied to me is that he did
6 not do a technical in-depth, detailed review of
7 the ATSDR models, which was very disappointing.

8 His response, the first words pretty
9 much wanted to set aside any criticism and concern
10 about the ATSDR models. He backed off of with
11 what, I think, were his criticisms. He couldn't
12 defend them.

13 Q. Do you -- do you know Professor -- I
14 think is it -- Prabhakar Clement?

15 A. I have met him occasionally. I have
16 had a few e-mail discussions with him. When I was
17 an editor of "Groundwater Journal," he had
18 submitted a discussion article and so we discussed
19 that.

20 Q. Have you spoken with him at all
21 about Camp Lejeune?

22 A. No, not that I recall. No, I don't
23 think so.

24 Q. Do you have any opinion of Professor

1 Clement?

2 A. Not really. I don't know his work
3 that well. He hasn't published as much as other
4 people in the groundwater field, but I know he,
5 you know, he certainly is trained as a groundwater
6 specialist.

7 Q. And in order to -- to have served on
8 the role on for the National Research Committee,
9 he had to have been elected as a member of NRC by
10 his peers; right? Or no?

11 A. No, absolutely not.

12 Q. Okay.

13 A. You -- most people who serve on NRC
14 committees are not members of the Academy.

15 Q. Okay. Do you know if he is?

16 A. And all those committees that are, I
17 was not a member of the Academy when I served on
18 those committees, and most of the people on the
19 committees were not members. So it's kind of two
20 different things.

21 Q. Okay. Understood. That makes
22 sense.

23 Do you by chance, do you know if
24 he's been elected to --

1 A. I am 99.9 percent sure that he was
2 not.

3 MR. ANWAR: Okay. I'm going
4 to hand you one last exhibit.

5 (Document marked for

6 identification as Konikow Exhibit 21.)

7 BY MR. ANWAR:

8 Q. Exhibit 21, and I'll just represent
9 to you this is the chapter about "Exposure to
10 Contaminants in Water Supplies at Camp Lejeune"
11 from the NRC report. The larger report from --
12 from -- about Camp Lejeune.

13 | Have you seen this before?

14 A. This is the 2009 report?

15 Q. Correct.

16 A. Well, I looked at the 2009 report,
17 but I, you know, I don't specifically recall
18 seeing this.

19 Q. Okay. I just wanted to ask you a
20 few questions about --

21 A. Sure.

22 Q. -- some of the conclusions they made
23 at the end.

If you turn to the second to last

1 page of the document. It's ending in 516.

2 A. Okay.

3 Q. The second paragraph states:

4 "ATSDR applied best practices and
5 cutting-edge modeling approaches to predict the
6 complex groundwater-contamination scenario at
7 Tarawa Terrace."

8 Would you agree with that statement?

9 A. Yes, sounds like a compliment.

10 Q. "The ultimate outcome of the
11 modeling was average monthly predictions of the
12 concentrations of contaminants in the water supply
13 to which people could have been exposed. Although
14 ATSDR recognized and tried to account for the
15 limitations and uncertainties associated with
16 developing its models, it is extremely difficult
17 to obtain quantitative estimates of historical
18 levels of PCE -- excuse me -- exposure to PCE and
19 its degradation products reliably on a monthly
20 basis."

21 Do you agree with those statements?

22 MS. BAUGHMAN: Objection.

23 Form.

24 THE WITNESS: Well, I mean, I

1 thought it was a challenging exercise and
2 difficult also, but they did it.

3 BY MR. ANWAR:

4 Q. It goes on to state:

5 "Reporting such model predictions
6 without clear error bounds gives the impression
7 that the exposure of former residents and workers
8 at Tarawa Terrace during specific periods within a
9 given year can be accurately defined."

10 Would you agree with that statement?

11 A. Well, I don't -- I disagree that the
12 predictions were presented without clear error
13 bounds. I thought pervasive in all the ATSDR
14 reports was -- were discussions of error bounds,
15 uncertainty, you know, how the results could vary
16 under a different range of assumptions.

17 So I thought they did a nice job
18 presenting clear error bounds.

19 Q. Can I ask you.

20 I guess for someone who may have
21 been at Camp Lejeune, a former service member or a
22 resident there, who was interested in looking at
23 ATSDR's simulated concentrations, looked at the
24 reports or turned to the reports.

1 Based on your experience, would a
2 layperson be able to understand the concepts and
3 the uncertainty analysis presented in ATSDR's
4 report?

5 MS. BAUGHMAN: Object to the
6 form.

7 THE WITNESS: I'm not sure
8 what a layperson would understand or get
9 from it. I think it's just highly
10 variable with a person depending on how
11 much background they have in statistics
12 and math and geology, if they have any
13 background at all or how much. You know,
14 I think that understandability in the
15 public would be highly variable.

16 BY MR. ANWAR:

17 Q. "It is the committee's
18 judgment" -- so this paragraph goes on.

19 "It is the committee's judgment that
20 ATSDR's model is suitable only for estimating
21 long-term exposure quality. From that
22 perspective --"

23 MS. BAUGHMAN: Qualitatively.

24 MR. ANWAR: "Qualitatively."

1 Thank you. I'm sorry.

2 BY MR. ANWAR:

3 Q. I'll read that again.

4 "It is the committee's judgment that
5 ATSDR's model is suitable only for estimating
6 long-term exposure qualitatively. From that
7 perspective, a single exposure category of
8 'exposed' appears to be applicable for persons
9 residing or working at Tarawa Terrace at any time
10 during 1957 to 1985."

11 Do you agree with that statement?

12 MS. BAUGHMAN: Object to the
13 form.

14 THE WITNESS: I -- I -- I
15 don't. No, I don't think I do because,
16 you know, you know, there they seem to be
17 relating it to either exposed or not
18 exposed and ignoring any of the scale of
19 variability in the concentrations.

20 So I think the ATSDR models
21 were better than that.

22 BY MR. ANWAR:

23 Q. Okay. That last paragraph on that
24 portion says:

1 "Efforts at historical
2 reconstruction of exposures at Hadnot Point will
3 be even more problematic. The contamination
4 scenario at Hadnot Point is so complex that the
5 committee judges that only crude estimates of
6 contaminant concentrations in the water supply can
7 be obtained."

8 Do you agree with that statement?

9 MS. BAUGHMAN: Objection.

10 Form.

11 THE WITNESS: Not completely
12 and, again, I point out that before I
13 served on the Hadnot Point/Holcomb
14 Boulevard expert peer review panel, I was
15 quite skeptical myself and, in that
16 sense, at that time maybe I would have
17 agreed with this statement.

18 But I learned a lot. They
19 explained a lot. I saw the final
20 reports. I think they did a good job
21 modeling, a reasonable. Modeling results
22 are reasonably reliable.

23 I think there's certainly more
24 uncertainty there than probably in the

1 Tarawa Terrace model, but I think -- I
2 think they were successful in putting
3 together a reasonable model.

4 They explained all their
5 assumptions and approximations, and there
6 clearly are assumptions and
7 approximations underlying the models,
8 underlying that. So that, you know, it's
9 there, but it's a good model.

10 BY MR. ANWAR:

11 Q. When we're talking about successful
12 in terms of putting together a good model, ATSDR,
13 do you think they were successful in putting
14 together a good model for providing information to
15 an epidemiology -- EPI study, epidemiological
16 study?

17 MS. BAUGHMAN: Object to the
18 form.

19 THE WITNESS: In recognition
20 that the epidemiological study did not
21 make an assessment based on the actual
22 concentration level in the calibrated
23 model, but rather a ranked form that kind
24 of removes some of that.

1 But, you know, without any
2 understanding of their epidemiological
3 studies, it seemed like the output from
4 the models provided something that would
5 be useful for them.

6 BY MR. ANWAR:

7 Q. Okay. And when you say the model
8 was successful, ATSDR was successful, and it was a
9 good model, are you saying that it was successful
10 and a good model for the purpose of estimating
11 exposure in individuals?

12 A. I don't know.

13 MS. BAUGHMAN: Objection.

14 Form.

15 THE WITNESS: I don't know
16 how it was used for exposure. I didn't
17 look at the exposure studies or the
18 epidemiological studies. So I really
19 can't --

20 BY MR. ANWAR:

21 Q. Okay.

22 A. -- say.

23 Q. Last question.

24 Do you -- what -- what is your

1 | opinion of Robert Faye?

2 A. Of Robert Faye?

3 Q. Yeah.

4 A. He seems to be a competent
5 hydrogeologist, primarily in the, you know, in the
6 practical application end of hydrogeology. He's
7 not an academic in the sense of producing papers
8 on research and theory, but I think he has a lot
9 of experience and knowledge in terms of field
10 applications, studies, the reality of geology and
11 the hydrogeologic framework and the use of models.

12 Q. When is the last time you spoke to
13 him?

14 A. Way more than 10 years ago.

15 Q. Okay. I really appreciate your time
16 today and your patience with my questions. I
17 think that's all I have. I'll pass the witness.

18 A. Thank you.

EXAMINATION

20 BY MS. BAUGHMAN:

21 Q. Dr. Konikow, I just have a few
22 questions for you.

23 A. Yeah.

Q. You were just asking -- asked

1 questions about what you meant by successful in
2 terms of the ATSDR models.

3 Do you have an opinion about whether
4 ATSDR was successful in estimating the mean
5 monthly concentrations of contaminants at Tarawa
6 Terrace?

7 A. At Tarawa Terrace? I think those
8 were reasonably reliable. Again, always
9 reasonable in light of the uncertainty and the
10 error bounds about it. I think the calibrated
11 models were provided -- they were successful in
12 providing estimates and in assessing the
13 uncertainty in those estimates. So I think that,
14 yeah, I would say they were successful.

15 Q. And do you have the same opinion for
16 Hadnot Point?

17 A. I do. Again, there it was a more
18 complicated problem and, you know, many people
19 probably would have thrown their hands up and
20 said, we can't do it. But they did it and, you
21 know, I think the important thing is they
22 carefully documented all of their assumptions, how
23 they got at mass loading, pumping rates, pumping
24 schedules, and assessing uncertainty in those as

1 well as uncertainty -- assessing uncertainty in
2 many of the physical parameters.

3 Q. Okay. If an end user wants to use
4 the mean monthly concentrations for an
5 epidemiology study versus an individual exposure,
6 right, how if at all would that change -- (cell
7 phone) -- let me -- let me start over.

8 If an end user wanted to use the
9 mean monthly concentrations to estimate an
10 individual's exposure as opposed to for purposes
11 of an epidemiology study, how if at all would that
12 change how the model would be developed?

13 And I'm asking you in your expertise
14 as a hydrogeologist.

15 MR. ANWAR: Object to form.

16 BY MS. BAUGHMAN:

17 Q. In other words, if you're using the
18 mean monthly concentrations for individual
19 exposure as opposed to an epidemiology study, does
20 that change how you develop the model?

21 A. It should not. You know, again, I
22 think I said it earlier, maybe this morning.

23 But what the end user does or
24 intends or wants really should have minimal impact

1 on the development of the model, other than to
2 make, you know, if the end user, who's paying for
3 the model study, says, I need an estimate at this
4 point in space, then, okay, you make sure that you
5 calculate it at that point in space.

6 But the model itself should not be
7 affected by the end use of it. In other words,
8 the model should do the best job they can. Get
9 the most accurate result they could. Calibrate
10 the model, document the model and its accuracy,
11 and then use the results whatever you want to use
12 it.

13 Q. And just to be clear, if -- if a
14 medical doctor wanted to use the mean monthly
15 concentrations to calculate an individual's
16 exposure as opposed to for some other purpose,
17 like an epidemiology study, would that change how
18 the hydrogeologist gets to what the mean monthly
19 concentrations are?

20 MR. ANWAR: Object to form.

21 BY MS. BAUGHMAN:

22 Q. From a modeling perspective?

23 A. Should not, no.

24 Q. Okay.

1 A. I don't think it would.

2 Q. Okay. Is there a difference between
3 the words "valid" and "validated" or "validation"
4 in terms of hydrogeology and water modeling?

5 A. These are terms that not everyone
6 agrees on their meaning or intent, but it's very
7 common that just using the word "valid" by itself
8 is generally okay. You're saying that it's
9 appropriate for what it's being used for.

10 The word "validated" it has, I
11 think, more of an implication that you've got the
12 right model and you prove that you got the right
13 model, and that's generally not accepted in
14 science that, you know, for all the reasons in my
15 published paper.

16 Q. So if when you use the phrase
17 "scientifically valid," is that another way of
18 saying that ATSDR adhered to generally accepted
19 methodologies?

20 A. That's -- yeah. You're using
21 standard practices, common practices, well
22 accepted, well-documented methods and approaches
23 that are well accepted, in other words, yeah.

24 MS. BAUGHMAN: Okay. Thank

1 you. I have no other questions for you.

2 MR. ANWAR: I have nothing
3 either.

4 Thank you for your time today.

5 MS. BAUGHMAN: You're
6 finished.

7 THE WITNESS: Okay. Thank
8 you all.

9 THE VIDEOGRAPHER: Please
10 stand by.

11 We're off the record at 6:23
12 PM. This concludes today's testimony
13 given by Dr. Konikow.

14

15 (Signature not waived, the
16 deposition concluded at 6:23 p.m.)

17

18 * * *

19

20

21

22

23

24

1 ERRATA SHEET

2

3 Page No. ____ Line No. ____ Change to: _____

4 _____
5 Page No. ____ Line No. ____ Change to: _____

6 _____
7 Page No. ____ Line No. ____ Change to: _____

8 _____
9 Page No. ____ Line No. ____ Change to: _____

10 _____
11 Page No. ____ Line No. ____ Change to: _____

12 _____
13 Page No. ____ Line No. ____ Change to: _____

14 _____
15 Page No. ____ Line No. ____ Change to: _____

16 _____
17 Page No. ____ Line No. ____ Change to: _____

18 _____
19 Page No. ____ Line No. ____ Change to: _____

20 _____
21 Page No. ____ Line No. ____ Change to: _____

22 _____
23 Page No. ____ Line No. ____ Change to: _____

24 _____

Golkow Technologies,

A Veritext Division

www.veritext.com

877-370-3377

Case 7:23-cv-00897-RJ Document 369-8 Filed 04/29/25 Page 360 of 455

1 DECLARATION UNDER PENALTY OF PERJURY
2
3
4

5 I declare under penalty of
6 perjury that I have read the entire transcript of
7 my Deposition taken in the captioned matter
8 or the same has been read to me, and
9 the same is true and accurate, save and
10 except for changes and/or corrections, if
11 any, as indicated by me on the DEPOSITION
12 ERRATA SHEET hereof, with the understanding
13 that I offer these changes as if still under
14 oath.

15 Signed on the _____ day of
16 _____, 2024.
17
18 _____

19 LEONARD KONIKOW, PHD
20
21
22
23
24

1 CERTIFICATE OF REPORTER

2 COMMONWEALTH OF VIRGINIA)

3 I, Denise Dobner Vickery, a
4 Registered Court Reporter and Notary Public of
5 the Commonwealth of Virginia, do hereby certify
6 that the witness was first duly sworn by me.

7 I do further certify that the
8 foregoing is a verbatim transcript of the
9 testimony as taken stenographically by me at the
10 time, place and on the date herein set forth, to
11 the best of my ability.

12 I do further certify that I am
13 neither a relative nor employee nor counsel of
14 any of the parties to this action, and that I am
15 neither a relative nor employee of such counsel,
16 and that I am not financially interested in the
17 outcome of this action.

18

19

Denise D. Vickery

20

21

DENISE DOBNER VICKERY, CRR, RMR
Notary Public in and for the
Commonwealth of Virginia

22

23

24

My Commission expires: March 31, 2026

Notary Registration No. 126014

&	132:18 152:16 152:16 153:4 164:2 221:14 266:15 268:22 312:10,13 313:19,20	228:10 265:2,4 265:10 266:8 267:16,19,23 288:24 289:20 332:21 122 188:3	160 296:22 1600 279:15 293:1 162 5:4 166 6:23 17 8:9 286:20 286:22 287:1
0	10 5:3,21 6:16 23:1,2 37:7,11 55:2 77:21 86:12,15 93:17 112:2 124:23 144:21 150:12 150:14 152:14 228:9 259:5,6 259:6 293:2 305:19 326:1 341:4 353:14 10,000 50:6 237:18 100 6:8 67:6 206:13 236:10 297:1 10003 3:17 11 6:20 23:2 66:17 156:23 157:1 194:11 341:4 110 143:14 11:06 83:13 11:15 83:16 12 6:23 55:3 66:17 86:16 93:17 151:17 166:9,11	123 230:9 126014 361:24 13 5:13,21 7:4 22:10,20 151:18,24 200:6,8 262:11 265:8 13101 2:16 9:11 132 6:10 139 6:13 14 7:14 176:9 186:10 242:5,7 262:12,13 265:17,18,24 266:23 15 6:6 7:17 205:4 268:18 268:20 150 6:16 15207 361:20 156 6:20 16 8:1 278:4,6 280:20 282:2 283:15,17 285:21 292:18 315:1	17,484.50 66:20 178 294:6,7 18 5:9 8:12 293:16,18 183 135:18 19 8:15 97:18 101:15 132:24 165:3,9 176:9 186:10 310:8 310:10 19.75 66:11 193 193:24 194:6,7 1940s 159:7 1942 159:7 1943 151:10,19 1953 97:10,13 98:5,11,18 152:10 174:2 188:19 189:24 275:15 1954 151:11,18 168:14 169:13 1955 151:12,18 1957 135:17 349:10
1	1 5:9 18:11,14 19:15 60:14 92:11 116:5		

1960	189:24	1992	6:22	20.2	105:23	201	276:12
1964	294:16		159:14 243:2	20.3	109:18	2012	243:8
1965	265:22		250:10	20.6.	128:20	2013	6:14
1968	132:24 135:3 170:1 171:20,23,24 173:16 267:24 268:13	1993	7:16 242:21,23	200	7:4 213:12		120:15 218:22
1977	6:18	1997	47:7	2000	167:18	2015	60:3,18
1980	45:1 194:21 196:17	1999	101:13,16	20044	4:10	20170	2:17
1980s	122:1 229:22	1:30	161:2	2005	7:2 20:8 32:14 33:23	202.616.4473	4:11
1981	39:19	1:43	162:2,9		85:14,17 86:2	2020	38:20,23
1982	39:19 96:24 97:23 99:2 124:8 126:12 152:9 152:10 159:10 165:11,15,21 195:10 197:4 197:17	1st	39:1 65:10		87:18 88:11,12		39:1 66:17
1985	97:1 132:24 135:3 283:20 349:10		2		90:5,6,9,13,17	2023	38:20,23
1986	8:14 293:21	2	5:10 7:16 20:22 21:22		91:5,23 99:10 100:13 166:14		39:2
1987	42:13		22:1 116:3		166:21 167:9	2024	6:1 65:10
1989	42:13 47:6		153:15 163:23 185:2,12,22 206:18 221:15 222:23 265:3 278:9 282:3,4 314:1 315:14		167:18 176:23 186:3 194:2,3 216:17 265:3 265:14		65:13 66:9,10 66:18,18 69:11
1990	53:15	2-1-6	282:14	2007	6:11 8:15	2025	1:15 2:8 5:13,14,17,21
1990s	128:13 128:14	2.9	308:3	2008	8:11		6:6 22:20 26:6
		20	6:9 8:18 86:12 101:19 103:5,8 124:23	2009	7:24 8:8 8:19 20:9	2026	26:10 67:17 361:23
			128:16,17,17 172:3 184:4		32:14 33:23 92:22 93:1,7 93:21 94:18	21	5:10,17 6:1 8:15,17,22
			189:16 212:6 272:7 293:2 331:10,12		99:11 100:13 117:2 167:9,18		26:10 66:10
		20-2	105:24		200:15 201:4,5 203:17,21	212.558.5915	345:6,8
		20.1	103:8		214:6 216:17	216	3:18 282:12
					216:23 268:23		285:2,16
					269:1 282:5,9 284:11 340:8	23	281:12
					345:14,16	242	7:14
						25	1:15 2:8 5:14 168:3

Golkow Technologies,

A Veritext Division

877-370-3377

www.veritext.com

Case 7:23-cv-00897-RJ

Document 369-8

Filed 04/29/25

Page 364 of 455

25th 9:7	3.3 239:14	40 30:2 40:2 137:24 155:4,5 155:6,13	53 169:18 332:23 333:10
26 267:8 270:11,16,19 270:23 271:14 271:15,24 272:7,17 273:1 274:2 275:2,9 275:13 280:11 280:21,24	30 8:8 124:23 152:7 159:16 160:21,23 184:4 201:4 205:6 239:5,6 239:12,13 279:15 282:9	400 65:7 67:18 43 159:7 45 160:23,24 295:17 296:8 46 265:11 326:5	57 269:20 271:8 59 271:20 326:6,7 328:4 330:6 5:01 297:15 5:43 330:14 5:51 330:17
268 7:17	293:2	47 168:3,3 266:15	6
275 65:14 66:11,19	31 7:16 66:18 240:7 361:23	48 168:5 49 176:8 186:6 326:5	6 6:3 65:21 66:1,16 164:1 259:6 276:13
278 8:1	310 8:15	4:05 261:18	300:10,13
28 3:6	31st 39:2	4:54 297:12	60 271:8,20
286 8:9	32 227:6,8,9	4th 315:9	61 271:20
287 6:12	329 8:21		63.58 66:19
29 7:2,24 166:21 201:4 269:1	33 22:9,17 231:13 287:5	5	65 5:22 6:3
293 8:12	331 8:18	5 5:22 65:19 66:1,8 135:16	663 7:3
29464 3:7	33271 332:2,8,9	154:6 259:5,5 282:19 285:2	68 265:23,23 269:23
2:28 199:9	33272 333:19	321:18,18 328:9	
2:45 199:12	340 4:9	5,431.25 66:12	7
2a 206:21	345 8:22	50 156:7 213:12 223:24	7 6:8 100:18,20 101:4 128:16
2b 214:7	35 5:18	297:1	185:1,5,22 269:11,13 284:7
3	353 5:5 3:51 261:15	50,000 137:18	7.1. 332:12
3 5:14 21:2 25:16,19 26:5 150:23 151:2 153:20 279:14 303:2 305:23 316:23 317:21 326:17	4	513 6:15 516 346:1 517 8:24	700 3:16 70s 40:4 71:19 71:24
	4		
	4 5:18 35:13,15 35:19 37:4 154:2 259:6 316:24 319:22 319:22		

73	291:10,14	95	334:15	344:11	300:15 346:14
74	294:16	95.3	336:7	absorption	accounting
79	79:8	99	201:8,9	206:10	266:12,20
7:23	1:4	99.5	337:20	abstract	accuracy
8		99.9	345:1	157:8	8:12
8	6:10 132:1,3 132:5 228:11 294:10 295:15	9:38	1:16 2:9 9:8	academic	131:5,7,19
			a	academies	143:1 155:21
80	79:8	a164	142:14	58:17,18 61:2	184:8,12 202:9
800	279:13 280:18	a182	142:10,12 142:13	academy	202:17 203:8
80s	71:20 72:1 163:10 215:17	a98	135:6,8,9 135:12	40:22 56:10,17	204:18,23
82	194:21 196:16,18	abandoned		58:1,5,7,11,12	206:6 214:18
824	6:2		244:9	58:13 59:5,15	215:9 216:21
827	6:7	abc	175:15	59:23 60:2,9	220:7,9 227:19
83	97:3		188:19 266:1	60:18,23 61:1	245:9 262:17
84	97:3	ability	267:12 270:22	61:16 340:2	263:17 264:2
843.216.9239			29:17	344:14,17	264:14 291:4
	3:8		103:13 112:5	accept	293:23 295:20
85	159:11 269:24		257:8 361:11	311:23	296:1,10
87	42:16	able	able	327:6	328:10 329:12
89	42:16 269:9 269:14	above	348:2	acceptable	333:13 338:17
89.9	336:7		64:11,15	228:4,6,11	356:10
9		above	196:6 287:18	256:13 323:21	accurate
9	6:13 66:9 139:22,24 265:8 278:9,10 285:3		289:1 290:10	327:6	35:24
		aboveground	290:12 313:7	327:6	59:2 66:4 98:6
			277:14	acceptably	111:23 158:2
		absolute	357:18,22,23	264:17	213:6 216:6
			326:20 357:13	accepted	224:7,11 225:9
		absolutely	357:18,22,23	118:5	225:15 234:2,6
			168:1 227:1	198:8 241:4,13	235:22,23
				241:20,23	236:6 240:14
				244:21 323:20	251:7,10 260:5
				326:20 357:13	263:3 264:17
				357:18,22,23	295:16 323:15
				151:5 329:24	337:10 338:4
				account	356:9 360:8
				118:19	
				191:17 299:3	
				299:15,17,18	
				299:19,22	

accurately	193:1 198:18	addressing	advances 243:5
110:15 181:11	208:23 216:23	172:19	advection
252:2 347:9	226:8 239:20	adequacy	302:13 317:17
achieve 322:5	269:21 271:4	155:22 203:1	advice 218:4
achieving	301:6 306:10	adequate	advised 334:4
214:24	315:5 317:18	182:11,13	affect 181:14
acknowledge	340:22	202:9,18	212:23 213:17
247:21 306:18	add 96:17	204:19,24	229:6 271:10
307:19	107:8 109:12	233:20	271:20 275:8
acknowledged	149:23 182:3	adequately	affected 73:22
305:15	184:13 326:22	203:4 313:3	131:8,20 210:8
acknowledges	326:24	adhered 357:18	356:7
300:6	added 67:7	adjacent 31:4	affects 214:3
acknowledging	170:17 205:15	adjust 255:16	afternoon 5:4
173:24 174:7	326:10	257:21,24	162:1,11,12
act 11:3	adding 184:9	258:10,12	age 132:18
action 130:5	184:11,17	259:20 260:13	agencies 58:24
361:14,17	additional	318:20 326:19	agency 59:4
active 298:5	43:11 325:19	327:10,11	63:16 132:16
activities 36:22	325:24 326:22	adjusted 319:2	191:16 192:8
205:24	326:23 327:1	322:5	ago 19:23 36:5
activity 39:12	address 167:2	adjusting 259:9	40:2 85:5,6
40:9,18,19	209:14 247:3	260:3,8	90:8 122:8
44:10 70:10	316:21 334:1	adjustments	156:7 172:4
74:20	addressed	326:20,23	184:5 188:15
actual 11:16	92:15 95:24	administrative	205:4 252:9
145:5 146:3	96:21 218:18	78:4	339:9 353:14
181:10 212:19	219:23 221:10	administrativ...	agree 57:6
334:6 336:4,19	221:21 222:2,6	78:12	60:12 100:21
337:14 351:21	301:11,13	admirable	100:24 110:23
actually 58:16	311:7,8,19	229:17	130:17 131:14
73:2,3 78:15	326:16 330:9	admits 306:9	145:3 156:2,8
123:20 124:11	340:11	advance 86:5	157:17 158:6
127:21 150:21		87:11	165:12,21

166:15 180:12	333:11	342:22 348:3	anwar 4:6 5:3
187:10 200:16	alexandria	analyst 183:4	10:1,1,21,24
272:23 287:13	77:17	analyze 159:13	18:12 19:20
287:17 288:12	alleviated	andrews 45:3	20:13 21:19,23
289:6 291:23	313:6	annual 33:9	24:17 25:17
298:14,16,22	allows 115:4	214:1	28:23 35:18
300:13 306:23	alluvial 6:17	answer 13:11	55:22 57:22
307:2 311:12	alternative	15:12 28:24	59:10,21 65:15
315:22 327:3	154:7,13	29:16 30:17	65:22 67:16
337:6 346:8,21	207:23 216:8,9	51:13 59:11	79:10 80:1
347:10 349:11	218:2	135:22 136:24	81:5 82:8
350:8	alternatives	137:20 138:4	83:17 86:1
agreed 305:15	214:23 217:15	139:3 143:12	95:10,13,18
339:23 350:17	amended 5:9	143:14,17,19	97:16 99:8
agreement	america 4:3	143:23 166:3	100:15,24
288:20	9:14 30:5	190:8 204:1	101:2 107:11
agrees 250:16	amount 63:5	207:17 236:12	113:13 114:5
326:8 357:6	66:12,20 67:3	236:14 237:15	114:16 117:19
agricultural	analogies 159:4	238:6 284:22	118:1 122:20
73:23 104:1	analyses 7:5	320:12	123:22 125:23
agriculture	55:5 128:10	answered	126:13,23
115:9	200:20 229:21	79:18 246:21	127:2 131:23
ahead 96:16	234:10 237:17	288:16	132:4 133:11
105:10,11	245:24	answering	133:20 137:3,7
110:7 156:23	analysis 7:1,18	143:21 149:20	137:21 138:3,8
204:3,7 220:16	8:2 135:14	answers 201:23	138:14 139:5
220:20 231:10	139:9 147:19	208:20 209:2,3	139:16,21
232:8 248:5	202:8 206:22	209:6 309:5	140:1 141:7,22
277:20 278:23	207:7 229:8	anticipated	142:9,15,18
aimed 50:23,23	240:2 242:24	56:11 206:22	143:22 144:3
246:9,11	245:24 252:21	anticipating	144:17,22
aiming 50:23	260:19,23	60:6	145:1,12
alex 4:22 5:10	262:24 276:1	antonucci 4:8	146:13 147:2
27:23 76:3,9	334:21 335:3	10:4,5	147:14 148:4

149:16 150:10	297:16 299:23	203:7 206:4	approaches
150:15 155:11	303:17 304:21	306:12 336:14	216:8 226:3
155:12 156:22	309:10 310:6	336:23 349:8	240:15 257:11
157:2 160:7,15	310:11 319:4	appendix 201:9	334:20 346:5
160:22 161:1,3	324:14 329:16	204:14	357:22
162:10 165:20	330:10,18	applicable	appropriate
166:7,12 169:6	331:8,13	349:8	131:9,21
173:18 175:4	333:14 335:17	application	207:12 214:15
179:18 187:2	335:21 336:13	45:24 128:23	215:6 232:16
187:19 188:4	338:14 345:3,7	129:5 190:17	241:14 255:5
190:18 192:7	347:3 348:16	212:8,11 353:6	357:9
193:2 196:22	348:24 349:2	applications	appropriately
199:2,13 200:5	349:22 351:10	353:10	260:21
200:9 219:9	352:6,20	applied 81:7,8	approval
220:19 222:3	355:15 356:20	81:10 154:24	128:13 256:12
223:15 224:22	358:2	241:16 329:22	approved 89:2
226:6 227:8,10	anybody 146:8	346:4	approximately
227:11 229:12	anyway 13:16	apply 44:2	259:3
230:10,13	335:18	155:2	approximation
235:8 236:11	apart 291:24	applying	171:8 181:11
237:14 242:3,8	apologize 51:23	240:10	198:7,12
247:8 249:4,19	252:12	apportioned	228:23
250:2 252:3	apparently	275:22	approximatio...
254:8 258:21	135:4 168:21	appreciate	198:1,23 323:3
261:13,19	203:14 204:15	145:23 330:22	351:5,7
263:23 268:16	268:24 279:10	353:15	april 7:24 8:8
268:21 269:6,8	283:11 321:21	appreciated	201:4 269:1
270:18 273:8	appear 214:15	313:23	282:9
277:24 278:7	215:5	appreciation	aquifer 6:17
284:23 286:12	appearances	42:23	48:13,15,16
286:17,24	3:1 4:1	approach	51:11 98:3
288:8 289:5	appears 22:5	183:1 202:14	108:24 110:3
292:5 293:14	172:18 177:1	203:6 206:4	111:10 113:7
293:19 295:4	201:15 202:14	214:21	121:24 126:11

145:17 154:9 154:14 170:23 174:10,13 175:9 189:2,9 189:23 191:9 302:4 309:24 320:19 aquifers 32:4 172:21 312:11 aral 28:9 29:13 32:9,12,22 271:4 area 31:3,4,6 38:10 48:12 62:19 74:3 93:10 96:12 105:4 116:11 205:12 276:4 294:15 308:21 308:22 321:5 321:10 325:6 325:10,11 areas 55:8 58:16,22 62:6 62:9 93:9 96:10,10 104:11 105:21 116:9 205:22 216:1 293:7 309:9 argue 241:24 254:11 255:9 257:12 291:1,2	argument 254:4 arizona 294:16 arm 56:10 58:1 aronov 4:17 9:5 arrival 172:10 173:15,23 266:21 269:20 270:9,15 arrivals 207:21 arrive 271:19 arsenal 6:18 73:19,24 74:19 75:6 148:19,22 149:4 150:17 150:21 151:6,9 152:15 155:1,3 162:23 art 43:5 45:20 81:3 91:21 224:20 226:4 245:14 323:20 article 150:16 152:15 156:21 157:3 160:9 242:24 293:20 294:4 295:24 296:6 342:11 342:15 343:1,2 343:18 asdr 16:5 aside 21:20 24:19 25:9	30:12 32:5 83:3 160:16 343:9 asked 24:24 29:16 40:8 44:9 51:23 52:24 70:19 75:7,8 79:18 84:19 85:18,19 85:21,22 86:5 87:2 93:2 122:8 126:23 137:17 143:12 144:13,20 162:22 180:13 188:3 222:12 230:4,4 244:23 252:12 257:14 257:15 288:16 353:24 asking 13:18 15:20 37:15 137:23 212:4 220:11 221:18 234:16 330:9 353:24 355:13 asks 21:2 304:10 aspect 49:22 50:1 aspects 112:19 assess 48:20 52:5 90:1 115:19 129:22	179:2 182:10 195:18 217:15 229:4,8 264:2 264:14 327:20 327:21 assessed 51:15 214:19 assessing 7:4 32:3 48:5 158:17 183:18 200:19 225:7 237:4 354:12 354:24 355:1 assessment 42:14,17,19 43:10,17 44:14 45:13 48:21 50:5 53:24 55:5 98:22 122:15 128:8 128:11 135:23 149:24 179:6 183:22 190:12 191:24 221:8 237:22 289:12 289:16 295:11 333:13 334:20 340:15 351:21 assessments 51:17 52:12 87:5 127:11 218:5 237:21 assign 328:9
--	---	---	--

assigning	188:7 216:3	224:6 227:19	99:13 116:14
329:12	228:23 273:9	229:16 230:19	116:18 132:6
associated	324:7 347:16	233:13 234:1	133:6 134:6
132:21 234:7	351:5,6 354:22	234:10 235:17	135:13,23
249:16 277:23	assurance	237:7 238:23	145:6 164:15
337:17 346:15	102:8	239:15 240:10	164:24 186:20
associates 45:4	assure 104:16	241:16 248:2	192:5 193:10
76:14,17 77:20	105:2 214:23	248:24 249:21	200:19 229:23
78:19,22 82:15	astdr 208:23	250:7,12,21	230:5 237:8
82:24	atlanta 86:10	252:21 260:22	239:15 240:20
association	88:19 89:16	268:14 270:5	244:14,24
30:4 33:6	166:20	273:10 274:14	245:16 247:17
80:10 136:8	atsdr 6:10,13	275:9,12	251:7 265:15
assume 13:3	7:17 8:1,9,18	290:20 297:24	281:8 305:10
46:15 64:15	13:22 16:5	298:14 300:14	310:20 331:15
93:2,3 118:3	18:2 32:14,23	308:16 310:19	340:6 341:15
167:16 170:12	34:3 68:4,16	311:4,12,17	347:23 348:3
178:19 186:15	68:18 69:5	319:5,10 323:7	348:20 349:5
190:4,4 206:9	72:3,6 76:16	323:10 332:17	attached 5:7
253:3 273:10	87:17 88:24	333:15,16	35:20 204:14
273:21 285:7,9	91:19 92:21	334:3,17 335:2	attachment
302:21 305:3	97:6 116:7,22	335:11,16	5:18,20 19:1
319:18	117:7 120:18	336:16 338:18	35:20,21 37:5
assumed	121:10 123:1,8	341:19 342:13	37:5
273:14 308:21	125:10 126:1	342:14,23	attempt 34:14
assuming 305:1	132:16 134:2	343:7,10 346:4	34:18 158:20
327:18	137:14 138:18	346:14 347:13	attempted
assumption	139:7 140:6,14	349:20 351:12	209:21
64:18 98:1,6,7	141:10 143:5	352:8 354:2,4	attempting
98:19 169:23	146:1,19	357:18	50:17 97:8
170:7,11 171:8	166:14 172:1	atsdr's 6:24 7:4	125:11 126:17
299:13 317:3	177:2 191:15	34:15 35:5	127:4 152:5
assumptions	195:21 196:11	85:10 88:20	158:10 237:10
34:19 170:14	208:23 214:10	90:17,18 91:4	255:15

attempts 207:8	available 97:17	256:14 319:14	backtrack
attend 167:23	97:19,22	340:5,10,17	292:9
attendance	123:12 151:24	341:14	backwards
72:17	159:17 164:14		46:24
attended 30:1	164:23 165:11	b	
33:8 76:14	170:22 193:23	b 5:20 37:5,5	bad 12:21 35:9
94:14	194:20 202:16	307:5	balance 131:4
attendee 71:6	208:18 218:3	back 22:7 35:9	338:3
71:22	272:17	71:14 83:15,18	balanced 109:4
attention 18:24	average 171:9	92:14 97:10	109:13
163:23 202:3	171:9,14	102:15 121:15	band 195:17,22
222:22	273:15,18	125:3 128:15	196:13 224:15
attorneys 17:2	298:1 302:6,9	146:16 150:24	base 7:10,23
17:3,4	302:22,24,24	151:18 152:14	8:7 132:21
audience 86:12	334:16 346:11	161:2 162:8,14	133:2 140:11
94:3,6 246:2,7	averaging	163:23 173:20	175:24 200:23
aura 243:23	228:24	180:21 183:20	based 29:12
247:13,20	avoid 12:6	185:6 186:2	34:21 50:4
248:22	244:18	193:20 199:11	64:17,18,19
australia 80:5	award 37:1	199:14 212:5	68:7,14 69:7
author 41:7	awards 36:23	214:6 222:22	69:13,13 79:12
80:20 99:17	60:15 61:5	242:19 261:17	108:15 113:16
authored	aware 23:19	261:20 262:10	115:14 118:21
156:18	25:11 26:13,16	275:14 276:19	119:17,18
authors 41:9	64:1,5,8,9,10	278:9,16 282:1	149:11 159:5
317:22	64:24 65:2,5	286:9 291:22	182:9,14
automated	81:12 99:7	292:7 297:14	190:22 191:1
258:8 260:12	121:12 124:16	297:17 330:16	193:3 204:1
automatic	125:20 126:14	341:13	211:3 212:1
258:7	126:16 127:3	backed 343:10	223:24 224:19
automatically	127:17 147:5	background	226:2 228:1
261:6	167:10,13	86:21 223:17	240:1,12,24
availability	213:14 217:16	348:11,13	242:24 248:15
229:20	237:9 238:9		251:19 252:19
			275:20 304:1

304:13 315:17	286:14 309:2	79:8 84:19	37:12 39:24
315:23 317:2	346:22 348:5	87:4,19 88:16	40:17 56:9
328:15,22	348:23 349:12	89:11 94:4	75:15 94:10
336:2,3,23	350:9 351:17	97:2,4,14	112:11 121:9
339:14 342:13	352:13 353:20	110:6 117:5	129:19 150:5
348:1 351:21	355:16 356:21	120:20 130:19	165:10 170:21
basic 108:22	357:24 358:5	138:13 147:8	171:13 172:13
253:9	bearing 199:16	153:12 196:24	172:13 179:10
basically 14:3	becoming 40:5	226:5 234:17	191:5 192:1,15
30:16 47:21	42:21	243:1,24	195:14,14,23
52:13 58:9	bedded 47:13	247:14 252:5	196:4 204:1
60:13 86:23	began 151:9	253:5 256:4	210:5 211:14
104:23 111:10	beginning	268:15 270:21	211:23,24
182:22 191:3	73:11 275:3	272:6 274:20	224:17,17
193:15 197:6	behalf 9:20,23	277:5 298:13	225:12 234:4
258:23 259:22	310:19 311:12	298:21 308:2	235:1 244:9
324:10	behavior	312:9 319:8	245:19 248:15
basin 294:15	121:20 123:3,5	325:18 340:8	251:18 253:12
basis 43:19	123:7 257:4	believed 96:4	258:11 259:1
92:6 187:7	belief 112:16	159:6 193:17	266:3,3 273:3
203:8 206:5	253:3 284:12	belong 124:18	281:14,15
213:24 214:2	311:18	belonged 29:4	299:8 318:22
223:23 230:18	believe 14:21	beneficial	322:6 339:4,17
232:2 233:7,11	16:8 18:1	103:1	346:4 356:8
233:17,20	19:23 22:22	benefit 103:22	361:11
289:24 317:12	23:13,21 25:24	103:23,24,24	better 113:15
320:1,18	26:20 27:4	103:24 104:23	180:18,23
346:20	28:15 30:17,21	benjamin 4:9	181:1,4 183:6
bates 332:2,5	31:3 32:14,17	bennett 77:4,6	184:1 211:20
baughman	33:3 40:20	78:2	250:24 253:20
3:15 5:5 9:22	43:4 45:3	benzene 140:9	264:19 281:5
9:22 107:5	63:14 71:6,14	165:15,24	310:2 323:15
174:24 220:12	74:19,24 76:14	best 29:17	324:1 331:3,4
269:4 284:21	77:16 78:9,15	32:15 36:6	349:21

beyond 73:22 187:7 276:5	blind 256:10,15	121:7 141:13 146:2,18	break 13:7,12 13:15 83:7,10
bias 295:21 296:11 297:5	board 33:5 bob 86:20 89:7 89:8,9,17,23	147:16 152:4 159:5 165:8	83:19,23 84:3 144:18,22
biased 185:20 279:4,5 280:8	310:22,23 311:10,11	166:20 200:22 205:11,19	160:19 162:14 162:17,22
big 48:4,6 78:9 221:4 278:3 283:5 284:14 285:19 293:8	bold 61:3 202:4 bolded 60:17 242:17	224:7 250:5 260:24 277:4,8 285:8,12 286:5	199:15 200:1,3 261:11,13,21 275:4 297:8,18
bigger 308:11 310:2	book 40:18,19 41:3,5 43:8 45:23 46:10	298:17 299:2 308:1,17,19,20 309:15 323:14	330:11
bill 4:22	80:21 100:22	324:15 325:1,5	breakthroughs 207:21
billing 66:2	101:1,5,8,12	325:12,14,17	bredehoeft 7:15 53:12
bills 21:3 66:2 66:22	109:18 128:16 128:17 129:2	325:21 350:14 bound 260:22	106:9,10,10,11 242:11,12,13
biodegradation 317:2,5,9,16,23 318:5 319:6,10 319:15 326:14 327:18,22	142:23 212:6 books 57:14 botlon 4:21	boundaries 73:22 111:5 boundary 98:13 108:3,8 170:13 190:23	243:1 250:10 253:4
biogeochemi... 181:10	168:3 229:13 239:13 243:9	190:24 192:4 213:21 257:22	bridgeside 3:6
biological 157:22	304:15 318:9 332:4	339:1	bringing 246:23
birth 132:22 136:8	bought 45:1 boulevard 3:6 7:9,22 8:6	bounded 260:10	brings 320:15
births 132:23	13:23 34:7,16	bounds 248:16 347:6,13,14,18	broad 57:20
bit 39:11 61:22 62:12 80:15 110:8 123:24 208:3 242:17 288:2 301:10	34:21 90:23 91:1 93:9,12 94:17 95:21 96:8 97:8,15 99:12 116:11 120:11,18	354:10 box 4:9 108:24 boy 281:4 breach 128:4 breaching 48:12	214:20 244:20 245:11
			broader 340:12
			broadway 3:16
			broke 325:8
			brought 40:12 40:13 88:23
			217:7 246:24
			316:7
			budget 113:11

buffered 257:3	calculates	286:4	162:4 258:3
build 112:13 181:22,24 182:1 183:24 264:17	calculating	169:11 195:14 195:23 227:20	calls 183:19,22 223:12
building	calculation	228:2 245:17	camp 1:7 5:23 6:4 7:1,10,23 8:7,23 9:12 11:2 19:6
264:18	197:10 303:20 307:19 317:19	245:19 255:5 255:12,22	21:11 30:22,24
buildings	318:16 322:17 323:4	257:19,21 258:6 260:9	39:7 62:23
205:23	calculations	261:2,5,7	67:23 70:2
builds 253:13 253:23	51:17 143:13	281:14 289:6	72:6 85:10
built 169:23 170:7,11,14	214:12 224:16	289:15,20	87:17 92:21
bulk 38:15 266:22 303:12 303:19 304:5 304:11,20,23 305:6,13,13 306:1,1,18,23	248:15 290:5 298:18 315:2	291:8,11,15 301:1 306:10	97:1 99:14 100:1 116:9,15
bullet 60:15,16 154:23,23	calibrate	307:8 318:11	116:19 121:11
burial 111:16	159:17 168:7 168:18 234:24 257:17,20 258:24 259:9,9	318:17 319:3 319:24 320:4 320:10 321:1,9 321:17,22	121:12 126:21 132:21 136:3 140:11 152:3 164:10,15,24
c	259:12 260:4 284:15 356:9	322:5,6 330:3 332:20,22 333:1,5 339:5	165:1,14,23 175:6 186:20 191:17 200:23
c 9:1 284:7	calibrated	339:17	215:20 240:20
calculate	151:8 158:15 224:18 229:18 231:17 248:15	california	250:12 308:7
133:17,18 276:18 304:1 307:23 356:5 356:15	260:21 271:7 280:6 281:1 289:12 304:17 305:5 307:5 351:22 354:10	158:9	343:21 345:10
calculated	calibrating	call 49:10 73:4	345:12 347:21
120:4 203:9 206:7 207:20 314:9	168:13 255:15 260:2 283:6 284:13 285:19	123:19 144:10 256:9 339:12	campus 88:23
		called 10:15	cancers 132:22
		31:4 38:1,2	136:9
		44:21 56:6	capabilities
		58:18 78:5	184:5
		80:14 102:6	capability
		125:7 148:10	153:1

captioned	cases	1:10 104:4,8 237:5	136:8 197:7 295:2 316:11	challenging
360:6			62:9 70:1	207:4 208:5
capture	263:5	324:7 339:23	77:23 80:8	229:17 347:1
care	142:6	casually	112:8 113:9,22	chance
career	37:23 38:16 39:14 73:18 236:24	categorical	116:1 155:2	67:9 94:3 214:24
careful	110:15 187:6 216:6	category	157:20 179:1	225:16 344:23
carefully	146:24 178:12 207:22 214:22 270:12 314:21 316:22 354:22	caught	207:17 213:17	chandler
carlsbad	47:12	causation	229:2 233:22	294:15
carolina	1:2 7:11,24 8:8 9:15 14:1,10 72:16 116:10 132:21 140:11 200:24	cause	248:11 273:14	change
carries	243:22 244:4 247:12	63:2,5 108:17 314:9 316:11,14	280:8 281:19	111:22 113:19,22
carry	247:20	caused	289:16 290:8	213:24 241:19
case	22:4 24:1 25:12 45:22 65:8 66:6 75:23 80:9 83:4 133:24 175:16 215:20 246:6 250:7 251:6 252:15 276:5 281:17 316:3 342:12	184:22 cautioned	293:6 319:13 321:8 327:6	293:3,8 296:21
		198:5 314:4	329:9 336:10 337:24 339:18	296:22 327:11
		causing	344:5 350:23	338:15 355:6
		cautioning	certainty	355:12,20
		216:6	223:3 223:10 224:8	356:17 359:3,5
		cautiousness	225:14 248:23	359:7,9,11,13
		255:1	260:22 326:22	359:15,17,19
		caveat	certificate	359:21,23
		25:5	361:1	changed
		caveats	certified	49:5
		244:1	2:21	changes
		cdc	certify	103:15 109:5 118:3
		88:23	361:5,7	258:1 294:14
		cell	361:12	295:14,18
		355:6	chairman	326:20,21,24
		center	44:17 53:10	327:12 360:9
		71:10	challenge	360:12
		central	208:11 209:18	changing
		217:9 280:3	challenges	113:16 259:22
		century	208:18	chapter
		166:20		6:9,10
		certain		6:13 8:9 16:8
		65:3 94:5 108:23		101:11,18,19
				102:20 103:4,5
				103:8,10

105:23 128:16 128:17,17 129:2 132:5 212:6,6 287:1 312:8 345:9 chapters 41:6 characteristic 122:21 193:18 205:9 characteristics 111:12,22 158:5 217:20 238:2 characterizati... 122:22 characterize 112:6 charge 202:4,6 340:18,19,21 341:8 charged 43:4 66:12 charging 65:11 65:12 charlie 45:3,5 chart 271:12 chats 19:5 check 15:9 284:7 330:12 chemical 74:17 74:24 110:2 149:12 153:16 157:22 181:10 229:21	chemicals 64:20 65:3 136:13 153:2 241:3 cherry 279:6 chief 30:19 38:19 childhood 132:22 136:9 children 136:9 chime 265:18 chloride 6:16 165:14,23 choice 131:10 chose 137:1 323:7,10 chris 53:21 circles 241:8 circumstance 73:16 257:17 circumstances 175:3 184:10 316:11 citation 106:8 cited 57:5 cities 103:24 city 31:5 civil 4:5 claim 21:1 243:24 247:14 249:18 claimed 250:21 317:22	clarification 12:22 145:23 class 71:6,13,15 cleaner 12:9 189:8 cleaners 175:15 188:20 189:14 266:1 267:12 270:23 clear 49:7 116:16 143:5 180:12 185:18 186:8 205:11 230:15 243:13 248:2,19 280:20 347:6 347:12,18 356:13 clearly 192:19 196:12 231:19 234:9 248:13 297:4 323:1 324:1 351:6 clement 341:11 342:10,20 343:14 344:1 climate 115:15 clja 6:12,15 7:3 7:12 8:20,24 332:5 close 65:3 253:23 292:15 292:20 293:1 295:17 309:22	330:11 closed 48:11 87:4 closely 130:5 255:17 300:20 339:23 clouded 207:18 coarser 182:15 coauthor 101:11 103:2 coauthored 101:18,19,22 129:3 130:12 130:14 242:10 code 78:16 80:14 81:1,9 131:11 315:17 315:23 codes 119:9 coefficients 118:8,9,10,13 193:15 207:16 251:24 collaborated 82:23 collaborates 82:23 colleague 72:9 102:4 colleagues 102:15,18 183:20 collected 111:4 283:22 288:4
--	--	--	--

292:23 293:11 319:24 320:3 collecting 168:9 collection 99:23 colorado 6:18 71:10 73:19 148:19 combination 259:2 combinations 245:8 259:11 274:21 come 16:4 35:8 48:11 69:18 73:16 85:16 92:24 226:17 234:5 250:22 291:22 292:6 302:16 comes 24:12 58:24 109:4 158:16 170:16 226:8 304:2 comfortable 236:3,5 coming 87:22 108:24 283:19 comment 90:1 178:13 202:12 209:13 236:1 278:24 284:5,6 285:19 286:2	311:21 327:7 327:16 328:4 332:12,17 335:15 commenting 177:9 222:18 222:19 236:4,6 comments 24:9 27:24 28:3 91:9,14 95:3,4 95:7,16 169:4 177:11 186:12 194:16 201:15 203:6,16 204:13 206:3 209:17 214:7,7 214:13 223:23 267:10 276:14 310:21 321:6 328:8 341:17 341:19,21,22 341:23 342:1,6 342:18 commission 56:4 361:23 committee 40:10 41:10,14 41:18,21 42:1 42:4,5,9,14,16 42:18,19 43:4 43:7,24 44:3,8 44:14,18,20 45:4,9,12 47:7 48:2,2,20	49:23 50:10 51:4,7 52:1,1,3 52:4,5,19,19,22 52:23 53:4,10 53:16,20,21,24 54:2,6,13,20,21 55:15,21 57:1 57:13 86:18 87:2 340:19,19 340:21 341:2,3 341:8 344:8 350:5 committee's 348:17,19 349:4 committees 32:19 39:14 50:14,21 55:24 340:4 344:14 344:16,18,19 common 104:24 118:6 124:11,13 commission 125:5 181:16 187:17 198:7 241:6 276:5 357:7,21 commonly 123:20 124:1 279:3 commonwealth 2:23 361:2,5 361:22	communicati... 19:6,14 20:24 21:13 73:2,6 community 79:14 243:14 243:15 244:10 company 44:21 44:23,24 45:1 45:2 74:17 77:16 79:9 compare 180:15 256:20 compared 96:3 217:20 262:20 315:2,4 320:6 comparing 255:22 287:8 295:5 comparisons 332:19 compensate 69:6 compensated 70:14 100:12 compensates 306:11 compensating 305:8 307:7 compensation 21:4 67:22 68:21 69:2 competent 249:17 353:4
---	---	--	--

complete 25:21 36:10 37:10 67:11 273:4	compliment 346:9	123:10,11 124:6 126:3,18	141:20 149:6 151:16 152:7
completed 74:12 116:22 117:2 120:14	component 48:1 191:14 304:4	127:5,22 133:18 136:18 136:18 143:7	153:17 158:11 159:10 177:7 185:17 192:10
completely 59:1 112:6 158:4 318:15 338:13 350:11	compounds 132:19 140:9 147:13	145:8 151:24 152:10 158:20 160:10 164:14	197:2 206:16 207:22 209:20 224:5 230:23
completing 229:17	comprehensive 204:4 237:2 242:24	164:17,23 165:6,7,10,13 165:22 168:12	230:24 231:23 233:5,12,19 234:1 235:17
completion 48:10 207:6 208:7	computation 328:11,12,20 329:7,23,24	178:20,21 179:23 181:15 189:22 193:23	237:11 241:18 251:6 271:10 271:21 281:9
complex 46:1 110:11 111:18 183:3 198:3 209:11 215:22 215:23 228:22 302:20 324:16 346:6 350:4	computational 182:14,16 202:8	194:21 196:17 197:11,17 198:19 205:6	287:15,21 289:19,21,22 290:8,15,17,21
complexities 198:21 206:23	computations 322:14	211:4 213:1 214:11 215:16	296:2 298:2 301:5 314:9
complexity 182:23 183:23 184:7,9,11 202:19 204:20 205:16 214:16 215:7,11 325:20,23 342:12 343:3	compute 110:2 134:13 140:18 177:6 298:2	229:19 234:19 282:24 284:9 287:9,10 293:1	326:18 327:9 332:22,24 334:19 337:3
complicated 354:18	computed 128:3 317:23	293:8 317:3,11 317:16 318:1	338:18 339:3 339:14,22
	computer 184:3,5 217:12	319:23 320:3,8 339:8,15	346:12 347:23 349:19 350:6
	computing 124:5 300:23	334:7,12,13 336:4,19,21,22 337:15 351:22	354:5 355:4,9 355:18 356:15
	concentration 96:19 97:20	concentrations 50:18,24 63:18 87:22 124:5	356:19
	98:17,23 99:3	125:12 126:10 128:3 134:12	concept 258:16 258:23 307:7
	110:2 121:21	137:12 140:17	conception 142:22

concepts 348:2	328:9	309:23 310:4	connotations
conceptual	concluded	conference	244:5
106:15,23	358:16	2:12	consensus 87:5
130:6 131:9,21	concludes	confidence	91:18
142:23,24	164:7 358:12	195:16 197:1	consequence
143:4 145:2,3	194:11	203:8 206:6	148:16 159:3
145:6,13,15,19	concluding	229:9 253:13	consequences
145:24 146:12	194:11	253:24 254:14	51:15 152:22
181:24 182:5	conclusion	264:17,18	conservation
263:6	223:12	301:3 324:3,4	105:14 108:16
concern 48:6	conclusions	339:6,18	108:20
96:13 98:18	155:14,16	confining	conservative
312:16,17,24	227:13 229:13	145:18 312:12	185:14,16,18
313:19,20	345:22	313:1,7,12	186:9,14,19
314:6,7,11,15	condition 98:4	confirm 20:18	consider 38:3,7
314:16 317:6,8	98:22 121:23	116:17 197:15	38:11 61:9,18
317:14 320:2,6	159:15 168:14	284:10	62:1,7,10
320:7 321:19	169:13 191:1	confirmed	72:11,14 188:8
321:23 322:21	258:3 317:10	145:4	193:5 195:18
343:9	conditions	confirming	195:20 216:8
concerned	98:13,14,15	273:11	259:17 291:4
92:13 244:6	108:3,4,8	conflict 312:20	312:1 314:21
312:18 315:12	113:14,16,17	confronting	consideration
concerns 48:5	113:20 170:13	207:5 208:7	63:16 196:10
91:22 92:9,15	190:24 192:4,5	confused 56:3	236:19 248:17
92:17 95:1,20	197:2 257:22	connecting	considerations
95:23,24 96:1	338:5,8 339:1	295:17	216:9
96:2 217:1,5,6	339:1	connection	considered
217:7 218:18	conducting	52:15 313:15	5:16 25:22
219:19,23	132:17 140:6	connections	26:9,15 34:24
221:20 222:19	336:16	121:6 325:16	51:15 57:3,4,7
311:5,13,19	conductivity	connects	57:15 58:16
312:5,6 313:6	118:12,17	119:14	59:15 60:3,9
314:1 326:16	197:20 228:9		
	260:15 308:11		

78:2 79:15 81:3 89:18 157:20 182:7 207:22,24 214:23 311:21 314:17 319:10 336:1 342:22 considering 192:10 301:8 313:16 323:5 consistency 338:1 consistent 77:13 117:3 166:24 197:12 225:13 241:19 260:16 333:4 consistently 221:14,15 constant 109:8 180:22 276:23 276:23 305:1 317:2 constituent 157:21 198:17 198:19 302:9 302:11,24 303:2 constituents 109:3 197:8 302:2 constitutes 110:11 145:17	consultant 5:22 6:3 79:9 consulting 45:2 77:16 79:13,14 contact 70:20 84:12,17,20 contacted 69:21 70:19 contain 19:13 23:24 24:21 contained 25:6 35:3 contaminant 50:24 63:2,5 63:14 86:23 96:6 97:20 98:3,20 116:9 124:12 125:12 126:17 127:4 135:16 136:18 137:11 143:7 145:7 149:6 151:16 152:6 152:10 153:21 158:11,20 185:17 192:10 202:19 204:20 206:15 209:20 224:5 237:11 240:16 266:23 270:4 281:9 298:18 303:8 334:16 335:6 338:18 350:6	contaminants 8:22 51:11 73:21 115:23 121:23 125:4 134:12 140:17 141:20 154:8 154:14,15 174:11 192:17 266:4 267:13 268:2 272:12 280:13 345:10 346:12 354:5 contaminated 46:5 121:24 124:19 132:20 134:14 135:15 136:2 140:19 168:10 172:21 174:2,8 270:23 271:1 272:1,9 contamination 5:24 6:5 39:20 40:4,23 41:15 46:14 73:21 96:4,24 97:9 97:10 122:2 124:15 151:7 151:11 152:20 152:24 153:5 154:22 157:13 159:5,8 170:1 171:19 205:13 271:17 272:3 323:10 346:6	350:3 content 219:24 context 32:11 49:15 74:9 169:3 175:6 178:13 284:19 286:16 332:16 continue 83:21 112:23 143:21 162:15 199:19 261:23 297:20 continued 162:4,7 259:22 continuing 266:17 continuous 313:1 335:7 continuously 275:2 contract 68:17 69:4 contractors 52:6 contribute 52:4 99:12 contributing 280:13 control 133:24 198:13 221:3 controls 105:5 conversation 24:19 84:4 193:3
--	--	--	---

conversations	76:2,4,7,8 80:6	219:4,10 222:4	345:15
19:5 167:11	82:5 85:11,12	223:5 227:3,4	corrections
coordinator	85:14,15 90:14	227:10 233:9	360:9
71:13	90:15,19 92:23	233:10 235:11	correctly 62:6
copies 66:1,4	93:22 94:12	235:12 238:18	103:17 106:17
copy 22:3 23:2	97:11,23 99:4	242:14,15,21	110:17,21
35:21 36:1	99:18 100:8,13	243:8 246:3,6	122:5 130:9
67:13 287:1	100:14 101:6	246:8 249:6	131:12 133:3
copyright	101:24 105:19	252:7 255:13	134:4 135:20
101:16	112:20 116:12	259:14 260:6	136:4,14
corollary 12:15	116:20,21	263:18,22	140:21 151:13
corps 7:10,23	117:10 119:4	265:15 267:5	153:6 155:24
8:7 132:20	119:24 120:6	269:2 270:6,24	157:15 168:15
140:10 200:23	120:19 123:12	272:4 273:12	168:16 170:4,5
correct 15:3	130:18 132:7	276:14 282:10	172:15,16
17:3 18:3	133:12 134:7	282:15 283:10	176:21,22
21:16 22:3,10	134:20 135:3	287:2,6,11	194:24 201:1
22:13 27:14	136:20 137:4	288:14 290:18	202:22 203:10
28:6 30:15	138:4 141:2,10	292:11,15,19	203:11 208:1
33:14 34:8	141:13 143:23	294:8,24	215:1 230:1
35:22 39:8,16	146:5 148:7,8	296:12 298:11	232:3 240:17
39:22 41:18	148:19 149:2,3	299:4,15,19	244:11 263:14
51:19 56:1	150:18 152:1,2	300:1,15	267:1 270:1,2
58:2 60:20,21	152:11,12,18	301:21 303:5	271:22 283:7
61:14,19,20	153:9,18,24	303:13,20	294:18 295:22
62:3,7,14,15,17	154:4,19	305:11 306:1	306:15 318:2
62:19,20,23,24	155:14 165:16	306:19,24	328:17,18
63:2,6,7 64:6,8	168:20 172:24	307:3,10,14	333:2,3 335:9
64:9,24 65:1,9	174:13,14,16	308:1,8 310:17	335:10
66:13,20,21	174:18 178:1	310:21 311:7	correctness
67:20,21 68:5	188:20 194:4,8	311:13,14	243:23 247:13
68:6,10 69:12	196:23 201:5	312:14,15	247:20 248:9
70:18 72:18,19	202:10 203:13	324:22 325:21	248:22
75:20,21 76:1	204:14 210:17	332:10 340:9	

correlation	courant	critique	d
275:24	221:1 221:13 314:22	92:3 193:21 331:15	d 9:1 46:5
corresponden...	course 82:21 207:9 271:9	331:21	data 97:17,19
19:4 20:6,24 30:23	court 1:1 10:11 11:17 12:1,9	critiques 92:18 95:20 223:21	97:21,22 99:4
cost 131:5	35:11 65:17 100:17 144:11	crossing 30:12	99:23 111:4
council 39:15 40:7,21 56:3,9 56:14 57:24 340:4,5	144:11 161:4 361:4	crr 1:23 361:21	112:13 119:14
council's 56:20 341:19	covered 20:1 20:11 24:4	crude 350:5	123:12 124:8
counsel 9:17 19:11 66:3 85:23 95:8 149:13 361:13 361:15	cows 51:10	cumulative 119:22 120:9	131:6 133:23
count 240:4	create 112:14	current 21:12	140:12 141:1,9
counter 240:8 256:5 279:8	created 109:2 226:9	36:3,4 135:16	151:21,22,24
countered 342:24	creates 63:17 221:4	263:1 334:3	152:9 155:23
countering 342:19	credibility 328:10	currently 21:14	159:17,18
counting 17:16	credible 229:19	25:11 26:13	164:10,14,18
counts 305:5	criteria 221:16	39:4 67:24	164:18,19,20
county 104:15	260:18	curriculum 165:3,6,11,13	164:20,21,23
couple 31:7 36:5 71:12 106:3 132:10 146:15 189:1 211:18 231:9 252:8 294:3 297:22 328:4	critical 134:9 287:20 342:14	5:18 35:22	165:16,22
	critically 48:22	36:1,8,16,20	168:7,9,18
	criticism	curve 283:18	170:22 187:7
	200:12 326:15	283:19	191:7,7 193:23
	343:4,9	cuts 284:3	194:20,21
	criticisms	cutting 346:5	196:17 197:3
	24:10 342:19	cv 1:4 37:14	197:17 200:14
	343:11	38:18 39:12,18	202:8,19
	criticized	42:12 47:6	204:20 205:1,2
	250:23	60:14 61:4	206:22 207:7
		cycle 274:5,11	208:18 210:6,8
		cycled 274:16	216:19 229:21
		cycling 271:18	229:23 230:6
		274:20	249:5,11
			254:19 255:4
			255:24 256:7
			256:10,16,18

256:23 257:9 257:11 271:15 272:16,24 279:22 284:9 287:18 288:21 288:24 289:24 291:24 292:1 292:12,13 295:16,19 300:22 311:3 317:23 318:5 319:23 320:3,8 321:16,22 322:13,17 326:19,21,24 327:10,11 328:16,23 329:22 330:1 339:20 database 214:17 215:8 215:12 date 9:7 151:18 201:3 270:5 323:9 361:10 dated 22:10 26:10 66:16,16 269:1 282:9 dates 66:9,16 97:4 117:6 190:2 dating 97:10 275:14	dave 93:14 david 27:3 33:18 davis 4:20 27:7 28:14 29:3,14 33:2,13,16 davis's 252:6 day 14:10 15:6 16:7,20 72:16 87:7 93:15 174:2,4,7 180:14 188:19 228:9,10,11 265:3 268:3,4 268:22 273:17 282:3,4 285:17 288:4 301:15 315:3 330:23 360:15 days 14:3 86:10 88:12 93:21 175:21 184:2 189:12 292:24 321:12 dc 4:10 dealing 89:21 dean 3:5 9:19 9:20 19:17,21 24:2 28:20 54:15 57:9 59:8,17 67:15 69:16,21 70:18 78:23 79:17 80:17 82:7	84:13 97:12 99:5 100:21 112:21,23 114:2,9 117:18 117:21 122:17 123:13 125:14 126:5,20 127:1 133:10,13 136:21 137:15 138:6,11,22 139:11,18 141:3,14 142:1 142:13 143:8 143:24 144:10 144:19 145:9 146:6,22 147:7 147:20,23 160:3,12,20 161:2 165:17 166:1 168:24 173:2,5 179:14 186:22 187:13 187:24 188:3 190:6 191:19 192:12 196:19 219:5 220:16 221:23 223:11 224:9 225:22 227:7,9 228:19 230:9,11 234:21 236:8 237:13 246:16 246:19 249:2,7 249:22 251:8	253:1 258:18 258:20 263:20 270:7 273:2 284:16 286:7 287:16 288:15 292:2 295:1 299:20 303:16 303:21 318:7 323:17 328:24 333:7 335:13 335:19 337:7 342:3 dean's 70:24 deanna 4:19 debate 241:7 243:17 decades 159:8 december 39:1 66:17,17,18 decide 36:15 129:19 182:15 189:22 195:13 234:12 decided 55:18 70:9 deciding 190:1 decision 69:19 decisions 183:23 declaration 360:1 declare 360:4 decline 318:1
---	--	--	--

declines 317:3	327:10 346:19	denver 71:10	360:10
decrease 184:12	degree 157:12 158:3 198:24	denying 178:14	depositions 28:13,17 29:13
decreased 317:11	207:10 208:18 210:2 223:3,9	department 4:4 8:18 10:2 11:1 47:11 48:20 75:2,24 275:1 334:4	deposits 47:13 depth 54:18 252:10 343:6
deemed 48:8	224:8,11	depend 198:18 203:1 258:3	describe 37:16 37:18,21 50:11 73:15 75:11
deeper 54:21	253:18 257:5	depending 198:18 348:10	108:17 118:20
defects 132:22 136:9	281:23 293:3 295:17 296:8	depends 57:12 175:2 228:14 251:9 257:5 337:8	180:13 210:11
defend 343:12	328:10 329:12	demonstrate 48:23 50:6 170:2	described 16:9 110:14 118:4,9 191:23 197:14
defensible 224:19 226:3	delivered 298:2	deponent 9:15	210:13 221:13
deficiencies 221:8	delve 54:20	depose 75:8	238:3 294:12
define 95:2 98:13 108:3 112:1 129:5 210:6 212:11	demand 275:20	deposed 73:12 74:9 75:10,18 149:18	describes 80:21 107:24 147:10
defined 96:11 96:13 106:14 184:15 263:8 324:1 347:9	demands 274:12	deposition 1:12 2:11 5:6,9 9:9 11:2,8,12	describing 116:7 240:15 244:13 246:14 247:17 251:2
defining 129:15 208:13	demonstrated 284:13	denise 1:23 2:20 10:11 361:3,21	description 75:17 107:3,8 145:21 232:12
definition 98:15 108:7 180:19,24 181:1,4 197:20 281:15	demonstrates 280:24 288:13	dennis 4:19	descriptions 210:10
definitions 106:6 210:7	denise 1:23 2:20 10:11 361:3,21	dense 175:24 176:5	design 128:23 129:4 153:4
degradation 206:11 317:12 317:15 326:19	density 303:12 303:19 304:5 304:11,20,23	density 303:12 303:19 304:5 304:11,20,23	154:2 212:7,10 213:2,18 214:4 234:23
	deoxyribonucleic acid 206:1,2,19,23	denver 71:10 8:18 10:2 11:1 47:11 48:20 75:2,24 275:1 334:4	

designating 78:10	determined 193:11	212:7 356:1	differential 98:12 108:2
designing 212:16	determining 126:19 127:6	237:3	difficult 80:3 106:7 207:4,16
desirability 193:18	deterministic 149:8 331:2	devin 4:21	208:5,11 257:10 346:16
desorb 302:16	107:15,19,20	dictate 309:11	347:2
desorption 302:7,19	108:15 109:7	differ 172:9	difficulties 207:5 208:6
destroyed 109:2	develop 31:6,9 74:1 149:10 150:6 182:5,7	173:22 307:24 207:18 217:9 217:14 218:8 273:23 306:21	313:11 difficulty 183:17
detail 54:23 209:14 219:14 219:15 317:18	191:5 210:2 234:24 355:20	308:3,5,5,10 314:2,8,13	dimensional 110:11
detailed 36:10 54:17 237:2 319:12 342:17 343:6	developed 93:10 116:8 133:7,16 146:1 146:3,12 151:7 203:4 208:10	315:6,14,18,24 316:10,21 327:20 357:2	dinner 76:23
details 32:19 89:4 214:21 272:19 275:19 311:9 317:7 321:24 322:9	236:23 249:15 250:13,14 355:12	differences 296:16 308:11 315:9	direct 18:24 33:10 83:1 160:8 163:22 216:1
detects 288:22	developing 31:24 80:13,16	different 86:13 111:21 112:2,3	directed 89:3 246:1,7
determination 334:24	98:9 181:19	137:24 143:17	directly 25:7 111:20 113:1
determinations 51:1 138:21 146:21 158:12 160:11 237:12	191:4 211:13 212:19 234:20 240:10 312:19 346:16	179:4 196:14 198:19 205:23 205:24 217:24 237:5 256:24	304:6 306:14
determine 6:20 135:24 136:7 149:7 179:12 209:22 335:4	development 78:16 104:19 128:23 130:7 131:6 150:1,8 177:6 190:21 210:1 211:1	259:10 262:23 271:6,6 274:6 274:11,20 275:23 278:1 291:5,7 293:12 294:21,21 315:3 344:20 347:16	directors 33:6 dis 207:13 disagree 57:20 129:12 167:6 168:23 169:7 169:11 240:5 313:20 321:3,5 323:6,9 326:15 328:8 329:10 333:12 347:11

disagreed	247:6 283:16	disposal	47:13
328:1	326:17 343:18	49:10 54:6	divide 312:23
disappointing	discusses	189:14 276:24	divided 89:14
343:7	326:14	dispute 144:19	dividing 312:21
discern 106:7	discussing 16:2	dissolved 110:2	division 1:3 4:5
discharge	45:17 212:7	153:2 176:3	9:7 89:13
153:22	267:18	197:8 241:3	divisions 60:24
discharges	discussion 28:4	distances	divorce 212:17
119:11	29:6,10 90:22	308:12	212:21
disciplines 50:3	93:11 167:17	distinguish	dobner 1:23
discontinuous	175:5 176:24	64:13	2:21 361:3,21
313:13	186:11 188:23	distributed	doctor 356:14
discover	234:15 265:18	178:20	document 1:9
277:12	311:2 343:2,18	distribution	15:10 18:10,15
discretization	discussions	7:7,20 8:4 38:5	18:16 19:1,10
213:2	15:17 34:23	38:7 87:23	19:13 21:21
discretizations	40:10,14 177:8	98:17,23	25:15,20 26:5
207:24	183:20 341:1	114:23 121:5	35:14,17 65:18
discretize	343:16 347:14	121:11 122:1	65:20 84:11
118:13 182:8	disease 63:2,6	124:7 133:19	100:19 101:14
discuss 14:5	335:5	159:20 181:2	132:2 139:23
25:6 35:4	dispersion	194:22 195:8	150:13 156:24
162:18 278:18	92:10 207:20	200:21 298:19	166:10 169:9
288:10	217:8,16	299:3 300:7,19	199:5 200:7,18
discussed 17:19	218:14 220:3	325:15	201:18 216:18
40:3 43:18,19	220:24 302:14	distributions	219:17,21
43:20 50:16,22	314:4,11	113:21 126:11	221:19 223:18
61:24 72:15	315:20 316:1,5	150:7 229:19	242:6 268:19
85:9 100:5	316:9,12,15	district 1:1,2	278:5,15
117:15 121:16	317:17	9:14 89:22	286:21 293:17
125:10 133:5	dispersivity	districts 104:14	297:7 309:3,4
142:22 175:11	207:14,15	disturbed	310:9 313:21
187:20 188:23	disposable	109:2	326:2 327:9
202:17 230:3	175:24		329:17 331:11
			340:1 345:5

346:1 356:10 documented 275:17 277:21 354:22 357:22 documents 14:22 15:1,11 15:23 16:6,16 16:20 17:7,11 19:14,24 21:3 21:13 26:3 65:16,24 68:7 68:14 69:8,24 84:9 86:7 87:10 135:14 173:9 203:5 204:2,6 209:1 217:4 218:7 225:4 310:12 doe 51:6 52:5 doherty 80:4,5 81:12,18 84:4 84:22 85:4 doherty's 84:12 84:12 doing 85:20 91:17 105:11 125:5 150:5 183:5 187:6 191:4 217:11 260:11 266:1 279:18 301:2 320:13,21 335:18	doj 75:4 doj's 75:24 domain 341:1 dose 51:14 doses 51:7 doubt 90:24 209:23 293:6 dougherty 93:14 downgradient 48:18 51:8 downstream 127:15 235:3 dozen 237:2 dozens 205:21 dr 5:10,11 8:16 10:22 22:2 25:21 32:12,22 76:3,6,9 77:2,2 83:5,5,20 107:6 162:11 164:7,9,13 168:6 176:10 176:14 185:13 185:15 193:22 194:15 199:17 200:11,12 227:18 239:17 239:20 240:9 261:22 269:19 276:17 278:17 291:13 297:19 300:6 301:14 305:9,24 306:8	310:16 330:20 342:20 353:21 358:13 draft 86:8 87:10 208:24 312:8 drain 174:9 drank 51:10 drawdown 296:22 drifting 218:10 drill 104:7 113:3,10,11 180:22 211:18 drilling 115:1 211:23 drinking 7:8,21 8:5 63:18 124:20 132:20 134:15 135:14 136:2 140:10 140:20 200:21 drive 2:16 9:11 drug 256:12,13 dry 189:8,14 305:14 due 66:20 111:10 296:1 302:12,13 316:15,16 317:15,17 dulles 2:15 9:10	duly 10:16 162:5 361:6 dumping 171:7 174:9 175:20 189:7 duplicative 287:24 duration 134:14 140:19 276:21 yncam 46:5 e e 9:1,1 19:3,23 20:6,23 69:14 73:1,5 101:23 102:1 201:9 343:16 earlier 34:2 61:24 72:15 85:9 97:14 100:4 125:9 142:21,22 149:17 152:11 163:11 230:3 234:15 237:16 242:11 282:22 299:24 311:1 355:22 earliest 97:17 97:22 early 53:14 71:20 72:1 73:18 122:1
---	---	---	---

159:7 163:10 207:21 215:17 easier 12:5 105:20 easily 152:23 eastern 1:2 9:14 economic 113:2 115:15 152:22 154:7,12 edge 346:5 editor 30:19 33:7 38:19 343:17 editorial 242:9 242:20,22 243:7 247:7 262:11 education 36:21 effect 43:9 104:15 107:2 107:21 108:17 148:17 159:19 184:17 198:23 218:13 220:7 253:19 258:7 269:22 300:23 302:18,21 334:9 effective 103:12,19 104:20 105:1,2 154:2	effects 115:1 136:1,12 140:8 147:11 149:24 179:2 190:16 207:20 220:2 334:18 340:21 341:6 efficiency 131:7,19 143:1 184:7 efficient 105:2 154:3 217:12 258:10 effort 120:11 130:4 211:14 238:4 efforts 90:17,18 91:4 92:18 94:18 97:7 99:13 115:24 116:15,19 164:15,24 182:15 191:5 340:7 341:15 341:20 350:1 either 28:12 41:5 71:19 75:7 77:2 107:9 182:13 206:10 316:6 335:6 349:17 358:3 elaborate 123:23 208:3	elected 59:6,13 59:14 60:2,17 344:9,24 electronic 22:16 element 102:22 109:1 263:6 ellipses 206:15 elusive 228:17 emphasis 211:8 334:6 336:18 emphasize 208:20 246:23 276:2 279:7 emphasizes 334:7 employed 100:7 employee 69:1 69:3 77:23 82:1,24 100:11 361:13,15 encompasses 38:13 58:21 encompassing 25:3 encouraging 263:13 ended 53:17 301:2 319:16 energy 47:11 108:16,21 109:8 123:23 208:3	energy's 48:21 engineer 53:20 102:3 engineering 6:9 26:8 58:12,19 60:3,18,23 61:16 101:6 191:5 198:1,6 241:4 340:3 engineers 118:6 enormous 208:5 enormously 207:4 208:5,11 ensminger 93:23 94:9 ensure 260:20 entail 105:8 enter 190:12 entered 53:16 68:17 entire 100:22 101:1 136:24 360:5 entitled 61:4 101:5 105:24 242:13 293:23 environment 110:10 111:9 215:22 308:13 environmental 43:10 63:15 79:11,12
--	--	---	--

113:17	epidemiologist	254:12 324:20	126:2 141:19
epa 64:2,21	62:14 94:10	err 188:6	143:6 145:7
74:23 128:11	139:2 187:16	errata 359:1	153:15,20
epanet 121:5	230:16 341:7	360:11	158:10 171:2
epi 125:12	epidemiology	erroneous	171:14 189:13
133:8 135:1	62:18 88:2	254:2	192:16,18,23
137:13 138:5,9	141:23 177:2	error 23:4	192:24 196:3,5
143:7 145:8	340:12 351:15	254:20 259:19	196:13 203:6
146:5 172:22	355:5,11,19	259:21 260:12	206:4 209:20
178:4 187:23	356:17	261:9 264:23	231:24 233:6
268:14 270:5	equal 52:3	297:4 305:12	233:14 236:21
351:15	288:6 291:2	305:15,16,24	237:9,10
epidemiologic	295:17	347:6,12,14,18	241:17 251:18
62:21	equally 259:3,7	354:10	273:15 276:3
epidemiologi...	equals 294:17	errors 227:24	276:20 279:17
62:22 88:3,7	equation 98:12	228:1 229:2,5	317:1 322:3
125:22 126:4	107:23,23	253:8 259:18	330:2 334:6,16
132:17 133:24	108:2,7,11	296:16,24	336:19 339:22
136:11,19	118:4,8,10	305:10 307:7,9	355:9 356:3
140:6,12 141:1	124:10 212:2	escape 48:6	estimated
141:9,24 172:1	217:23,24	especially	127:22 136:17
176:16 177:3,9	218:1 221:17	314:5	137:11 185:16
177:12,18	241:9 251:24	esq 3:5,15 4:6,7	211:8 233:20
229:24 230:7	304:4,7,13	4:8	272:21 301:5
230:20,22	314:3,14	essence 307:8	304:18 317:8
231:21 232:24	316:16,18	essentially	318:11,19
233:2 334:3,5	338:6,24	20:23 125:6	334:11 336:21
334:22,23	equations	220:18 255:14	339:1,13
335:3 336:11	180:17 193:16	276:22	estimates 133:7
336:15 337:2	217:10 241:3	est 1:16 2:9	134:1 140:13
340:12,20	241:11,21	establish 64:2	146:5 159:24
351:15,20	251:21,22	estimate 50:17	170:21 171:1
352:2,18	equivalent 23:2	71:21 87:21	185:16 192:1
	23:7,9 98:2	115:16,23	212:24 225:12

226:2 275:20 276:7 279:5 304:19 310:4 340:24 346:17 350:5 354:12 354:13 estimating 50:24 151:16 160:10 192:9 192:19 207:12 303:23 305:13 306:12 317:12 348:20 349:5 352:10 354:4	evaluation 319:12 event 306:6 events 75:19 76:23 257:1 eventually 87:15 evidence 191:2 192:3 227:21 252:20 280:8 281:10 334:21 evolved 121:21 ewing 53:20 exact 97:4 159:11 225:6 225:24,24 341:17 exactly 16:14 26:4 56:15 73:1 85:21 86:16 93:22 172:4 180:4 181:7 183:13 197:23 206:12 219:1 225:6,16 273:13 291:18 316:14 319:20 327:24 338:9 examined 5:2 10:15,19 162:4,7 353:19 examine 325:1 10:16 162:5	examining 262:22 example 55:20 148:19 149:2 156:12 188:11 271:14 284:6 296:17 examples 45:23 45:24 46:8 146:15 148:6,7 148:21 149:5 238:12 exceeded 63:20 135:15 221:1,2 exceeding 63:19 excellent 91:21 342:19 except 19:18 39:5,7 109:2 322:2 329:6 360:9 exceptions 202:16 excerpt 101:5 exchange 234:16 267:3 302:5,19 exclude 320:3 exclusion 250:19 319:23 excuse 50:18 66:17 68:12 74:12 81:8	95:10 129:2 130:13 155:6 236:13 258:19 260:3 282:3 308:18 326:7 326:23 346:18 exercise 148:14 245:12,16 347:1 exhibit 5:9,10 5:14,18,22 6:3 6:8,10,13,16,20 6:23 7:4,14,17 8:1,9,12,15,18 8:22 18:11,14 21:22 22:1 25:16,19 26:5 35:13,15,19 37:4 65:19,21 66:8,16 100:16 100:18,20 101:3,4 116:3 128:16 132:1,3 132:5 139:22 139:24 150:12 150:14 152:14 155:6 156:10 156:23 157:1 163:23 166:8,9 166:11 185:2 200:6,8 242:4 242:5,7 262:11 265:2 268:18 268:20 278:2,4
--	---	--	---

278:4,6,9 282:2 286:20 286:22 287:1 293:16,18 310:8,10 331:10,12 345:4,6,8 exhibits 5:6 66:1 exist 117:16 165:15,24 166:5 167:14 249:13 299:22 307:9 existence 91:1 existing 59:13 exists 197:16 197:18,19 303:12 expect 36:20 175:11 178:22 279:24 expected 50:5 86:18 293:4 expensive 113:9 experience 11:11 79:12 182:10 224:1 263:8 321:10 321:14 342:13 348:1 353:9 experienced 236:16	experiment 49:8 experimental 49:3 experiments 182:12 expert 1:12 2:11 5:14,23 6:2,4,7,23 7:4 7:17 8:1,17 19:7 20:8 21:12 22:3 24:8 26:7 28:18 29:1 32:13,18 35:20 38:4,6,8,11 39:8 53:23 55:11,16 62:7 63:1,3,4 67:24 68:4,16,22 69:10,19 70:3 73:8 75:13,23 76:6,15 85:10 85:13,17 86:3 86:15 87:18 88:11 90:5,13 90:14 91:16,18 91:23 92:17,21 93:1,7,24 94:10,14,18 95:5 99:9 100:6 166:14 167:9,18,19,23 175:6 176:23	187:15 200:14 200:19 201:3 201:10,17 203:17 204:10 214:7 216:18 216:23 218:17 219:4,19,22 221:21 222:15 223:22 226:13 246:5 250:6 252:15 265:3,5 265:14 268:23 282:5 284:11 285:11 288:10 291:3,9,9 299:5,11 311:22 335:22 336:10 341:9 342:8 350:14 expertise 41:22 55:9,21 61:23 62:1,19 102:21 341:5 355:13 experts 40:11 41:18,24 42:3 50:2 55:3 56:24 76:1,2,3 93:18 246:11 299:6 341:7 expires 361:23 explain 279:23 284:8 301:23 explained 69:22 70:1	112:17 317:5 328:12 350:19 351:4 explaining 322:24 explanation 313:17,22 explicit 91:9 exposed 51:9 176:17 177:19 179:13 190:4 334:8 346:13 349:8,17,18 exposure 8:22 50:18 51:1,14 63:5 64:11 126:19 127:6 127:10,14,19 128:2 133:8,23 134:2,14 135:23 136:2 138:20,20 140:12,19 141:1,9 146:4 146:20 147:12 158:11,21 159:24 160:11 172:11 173:24 177:10 178:4 188:8 209:22 214:11 231:24 233:6,15 237:10,11,19 238:7 334:8,9
--	--	--	---

334:10,13	320:19 346:16	302:1,23 303:2	falls 279:13,16
335:4,24	f	303:7,13,20,24	familiar 18:17
338:12,22	f 5:12,22 6:3,19	304:3,12,14,19	78:18 80:4
340:15 345:9	8:9,14 23:4	304:24 305:11	101:8 148:22
346:18 347:7	283:15,17	307:18,23	familiarity
348:21 349:6,7	285:21 287:1	318:13,20	70:2
352:11,16,17	292:18 312:8	325:24	family 133:1
355:5,10,19	f12 287:6,8,13	factored 184:6	135:24
356:16	288:12	factories	family's 135:19
exposures	f16 278:10	103:24	fancy 182:22
132:19 133:17	280:5 285:14	factors 129:22	far 21:17 165:2
140:8,14 149:7	292:13	157:11,20	202:15 225:2
149:8 350:2	f33 287:5,5	303:23 304:1	244:5 265:7
express 223:20	290:13	facts 15:9	334:11 336:20
expressed	face 208:10	factual 165:2	farmer 127:15
91:23 92:17	229:22	failed 332:22	237:20
221:20 234:10	faced 208:16	failure 157:10	farmers 51:8
242:23 311:9	279:21	fair 12:13,14	73:23
311:13 322:21	faces 208:17	12:19 13:4,13	fast 48:15
expressing	209:8,18	41:20 47:5	faster 258:9
248:20	facilities 74:18	54:4 86:11	fatal 321:8
extended 31:8	74:19 88:21	90:11 122:15	fate 8:10
274:2	277:16	122:21 167:16	117:11 119:3
extensive 71:8	facility 88:24	286:13 303:4	197:8 315:21
extent 151:15	89:3	303:10 309:24	316:2
210:23 272:16	fact 38:1 61:17	333:13	father 78:2,6
321:7	75:12,16	fairly 71:8	faye 86:20 89:7
external 150:1	173:19 230:6	118:4 176:1	89:7,8,9,17,23
externally	304:2	256:22 264:16	283:12 284:3
304:9	factor 181:9,12	276:23	285:20 311:10
extrapolations	181:16 198:1	fall 58:5,17	311:12 318:4
263:2	198:17 301:11	59:3 260:21	322:10 326:8
extremely	301:19,21,24	295:19 332:20	328:7 353:1,2
175:18 290:6,6			

faye's 310:22 310:23 313:19	322:12,17 326:19,21,24	fine 142:20 213:3 221:12 328:2	204:16 212:8 212:10 215:4
feasibility 154:7,13	327:10,11 329:22 344:4	finer 180:2,3 180:18 182:13	219:1 228:13 230:22 242:17
feasible 65:4 113:2	353:9 fields 31:6	finished 74:23	243:11 247:9 253:11 269:20
february 1:15 2:8 8:15 9:7	figure 279:1,9 280:6,20,24	107:6 134:13 140:10,18	270:9,14 305:23 315:11
federal 59:4	283:15,17	149:19 220:13	315:13,16
feedback 91:3 91:7 94:16,21 209:3 211:11 211:19	284:12 287:6,6 287:8,13 288:24 289:20 292:18 294:10	220:18 271:13 271:16,21 358:6	317:20 322:12 327:14 330:6 342:21,24
feel 213:5 236:3 236:5 259:1 264:19	295:15 315:10 figures 278:19 294:23	finite 102:21 207:18 217:9	343:8 361:6 fit 195:14,23
feelings 222:14	file 119:10,13	217:14 314:2,8	196:4 224:17
feet 112:2 189:16 213:12 213:13 228:9 228:10,11 296:23 297:1,1	119:14 filed 21:1 files 20:7 75:6	314:13 315:14	224:17 245:19
fell 291:14 296:7 332:24	final 218:17,19 218:21 219:1 350:19	firm 79:16 82:1 203:7 206:5	245:20 248:15
felt 24:10 61:10 91:16 92:14 222:5 232:11 232:16 233:19 236:16 316:19 316:21	finally 274:3 financially 361:16	first 11:15 19:3 27:16 35:19 40:16 53:10,16	253:12 258:11 259:1,3,7,18,20 259:23 261:3,6
field 99:23 110:16 224:21 274:10 317:23 318:5 321:22	find 111:21 163:9 213:11 252:20 307:20 310:1 342:5	66:9 71:16,18 89:10 106:3 109:22,22	281:15,15 287:21 289:21 291:11 296:1 318:22 322:6
	findings 6:11 6:14 16:10 62:18 132:6	110:19 114:19 116:4 119:10 121:16 129:1,4 129:16 130:3	five 30:18 42:7 54:1 85:6
		135:1 143:14 151:20,24 159:9 172:10	154:23 203:24 211:22 269:22 279:12 283:21 283:21 292:22
		173:23 174:7	293:10
			fix 149:14
			fixing 95:13

flaw 321:8	focus 32:3	47:18 54:15	273:2 284:17
flew 13:24	48:19 54:12	57:9 59:8,17	286:7 287:16
flow 16:10	93:11 124:6	78:23 79:8,17	288:15 292:2
31:17 38:8,13	144:23 176:24	80:17 82:7	295:1 299:20
46:15 48:3	177:5,8 227:12	97:12 99:5	303:16,21
49:19 50:4	234:19	104:13 112:21	318:7 323:17
52:10 62:2	focused 20:5	114:2 117:21	328:24 333:8
74:2 86:22	27:22 31:5,12	122:18 123:13	335:13,20
91:20 103:13	45:20 52:9	125:14 126:5	337:7 346:23
108:2 109:18	88:16 90:16,18	126:20 129:20	348:6 349:13
110:13 116:8	93:8 99:10,11	133:13 136:21	350:10 351:18
117:15,20,23	265:15 340:13	137:15 138:6	351:23 352:14
118:14 119:2,9	340:20	138:11,22	355:15 356:20
119:15,17,18	focuses 243:11	139:11 141:3	formed 44:24
119:24 120:19	focusing	141:14 142:1	former 347:7
122:10 145:16	163:24 325:9	143:8,24 144:6	347:21
150:2,3 151:8	325:10	145:9 146:6,22	forming 25:22
158:3 173:12	follow 28:22	147:7,21 160:3	142:24 235:13
203:3 208:9	87:7	160:12 166:1	331:21
213:9 240:16	followed	168:24 173:2	formulation
241:2 256:23	196:10 217:19	179:14 186:22	130:6 131:9,20
266:2,11,19	follows 10:17	187:13,24	forth 183:20
296:24 298:1	162:6	190:6 191:19	185:7 361:10
300:16 301:3	forecasting	192:12 196:19	fortunately
325:13	46:23	219:6 221:24	278:2
flowing 114:23	foregoing	223:11 224:9	forward 20:4
153:3	361:8	225:22 228:19	46:23
flows 120:3	foreword	234:21 236:8	founders 44:21
fluid 103:15	132:11 140:3	237:13 241:11	four 30:20
170:16 241:2	140:24 147:9	246:16 249:2,7	38:22,23 85:5
flux 103:15	forget 282:1	249:22 251:8	86:6 89:14
fluxes 119:12	forgive 62:13	253:1 254:10	203:24 269:21
120:3 241:17	form 19:17	258:18,20	fourth 231:10
	24:2 28:20	263:20 270:7	

fraction 23:3 23:10	291:24 306:7 361:7,12	255:1 312:21 343:3	geologically 118:21
frame 71:17 113:19 265:13	future 48:10,17 50:7 51:7,19	generalize 175:2	geologist 53:19
framer 210:4	51:21 115:9,19	generally 56:22	geology 348:12 353:10
framework 43:10 49:21 86:22 111:10 113:3 190:23 208:12 214:20 215:18 308:14 353:11	121:19 123:3,5 127:10,13,14 127:21 237:18 237:20 250:14 255:11 257:5 263:3,12 264:9	57:6 59:15 78:18 79:15 81:2 119:8 124:16 174:22 174:22 193:6 313:7 325:6 331:3 334:23 339:20 357:8	geophysical 111:20 180:24
frank 44:17	fuzziness 196:12	357:13,18	georgia 166:20
franklin 4:9	fuzzy 194:23 195:9,12 196:1	generate 47:18 119:10 343:2	geotrans 44:22
fred 106:9		generated 74:24 313:10	getting 78:5,8 138:2 176:3
free 52:7		generating 47:21	304:22
frequently 57:5 283:21,22 328:15,22	g	gentleman 101:23	giovanni 4:8 10:4
friend 72:11,14	g 9:1	geochemist 53:9,19	giovanni.ant... 4:14
friends 44:22	garbage 47:22	geologic 111:10	gist 180:11
front 166:17,18 327:16	garrick 53:23	111:11,13,15	give 21:6 24:15
fuel 47:17	gate 89:1	260:16 308:13	24:16 70:20
full 49:4 70:10 74:4 151:4 155:17,19	gather 71:20	308:13	75:9 146:14
fully 77:21 313:23	gene 4:17 9:5	geological 30:5	199:4 238:12
function 261:8	general 14:5 57:2,13 64:12	37:24 38:16	239:10 252:9
funding 58:24	72:12 78:20	52:14 68:9,17	259:1,3 266:21
further 34:9 42:12 130:21 162:6 259:23	81:9 117:14 126:22 153:14	69:3 71:5	288:6
	154:21 155:1 158:7 180:11	89:10,13 100:7	given 94:3,7
	182:4 211:10	100:11 102:3	201:24 214:16
	211:12 216:11		215:7 265:6
	243:15,21		291:12 324:7
	247:11 253:3		347:9 358:13
			gives 196:5
			259:6,6 265:24
			266:8 267:16
			291:5,6 347:6

giving	22:20 173:16	55:18 56:13 60:5,5 65:15	278:1 283:5 284:14,14	339:20 350:20 351:9,12,14
glanced	27:16	65:16 78:5	286:19 293:14	352:9,10
go	11:11,12 22:1 30:5 89:1 89:2 96:16 130:1,21 133:21 155:17 156:23 168:4 171:16 172:6 174:13 180:21 186:2 199:6 202:24 215:7 219:15 220:16 220:20 232:8 233:2 248:5 256:23 265:9 271:2 276:18 276:19 278:23 283:24 300:24 303:23 305:19	83:11,12 86:9 87:23 96:17 100:15 107:8 121:15 125:2 131:23,24 137:19,21 139:21 143:10 143:11,19,20 144:4,7 149:23 156:22 158:23 160:17 161:5 166:7 168:10 169:22 170:6 176:1,15,19 177:3,13,17,21 177:22 178:6 178:16 179:2 179:21 182:1	297:11 302:8 302:20 310:6 330:13 332:1 337:19,20 345:3 golkow 9:6 good 9:3,19 10:22,23 11:14 13:17 59:24 75:16 79:15,21 83:8,9 104:24 105:11 114:20 130:23,24 131:3 160:18 161:3 162:11 162:12,13 184:16,20 185:8,19 186:9	goodness 261:3 gordon 77:4,6 78:2 gospel 195:19 gotten 67:8 govern 108:1 197:7 241:2 governing 98:11 104:22 107:22 118:4 124:9 180:17 182:6 193:16 193:17 212:2 217:10,23 241:9,21 251:20 304:7 314:3 government 43:1 58:24 68:24 74:23 139:20 grab 199:5 grains 302:3,5 granted 128:13 graph 271:12 272:19,21 graphic 278:10 278:14 graphs 195:22 great 252:10
goal	142:5 334:17 335:2	183:8 184:14 185:2,6 187:7	196:10 216:11 225:16 226:2	
goals	52:4	194:23 195:5,9	232:12 234:12	139:20
goes	109:4 136:6 142:13 186:16 211:14 284:8 329:20 333:17 335:1 336:20 347:4 348:18	195:13 199:4,8 205:23 210:3 211:3 212:5 213:1,17 220:14 238:4 242:3 243:19 251:14 253:8	235:18,21 236:2,4 254:15 255:2,4 259:3 259:7,17,24 260:5 264:3 279:17,18,19 281:12 287:22	
going	13:6 21:24 25:18 35:11 49:7	261:14 265:18 266:10 268:16 277:1,7,18	289:14,23 301:4 313:14 324:6,13 338:2	

greater	188:9 284:1	50:4 52:10 62:2 70:7	224:1,21 229:21 236:22	218:4 220:11 221:18 238:6
greatly	104:10	73:20 74:2	240:10,16	257:14 272:1
grid	180:2,18 181:3 182:2,8 182:13,15 213:2,3,11,22 220:1 221:3 235:5 257:23 314:23	81:8,11 86:22 89:12,19,21,24 91:20 101:6,20 102:2,7,16,20 102:24 103:12 103:20,21 104:22 105:3	243:8 249:10 249:16 250:11 250:13,17 251:2,3 256:5 256:18,19 257:2,4,10 266:2,11,19	283:20 285:18 292:8 304:22 310:20 325:22 347:20 guessing 176:14 177:16 266:22
ground	6:21 7:14 8:12 11:12 30:3 33:6 42:14,17 42:19 43:16 45:12 80:9 81:7 152:20,24 153:3,5,21 158:1 175:8 189:7 192:17 242:13 243:22 244:10 247:12 293:24	107:14 108:1 110:1,13 111:6 113:23 114:6,6 114:11,23 115:12 116:8 117:8,17,23 119:2 120:19 121:19 122:9 122:11,11 123:2,4 124:15 124:22 125:21 150:2,3 151:8 151:10 154:21	276:3 291:23 293:21 296:24 300:16 301:3 302:12 340:22 340:23 341:5 341:10 342:8 342:11 343:17 344:4,5 346:6	guest 80:10 guidelines 216:11 260:7 guys 160:22
				h
				hadnot 7:8,21 8:5 13:22 16:16 34:6,15 34:20 90:22 91:1 93:8,12 94:17 95:21 96:7 97:7,14 99:11 116:11 120:10,17 121:6 141:13 143:6 145:7 146:2,17 147:16 152:4 159:4 200:22 205:11,19 209:10 215:23 219:12 224:7 250:4 260:23
groundwater	5:24 6:5,8 7:6 7:19 8:3 16:10 30:20 31:14,17 31:23 38:4,8 38:12,20 39:20 40:3,23 41:14 42:21 43:2,5,9 44:14 46:12,15 46:16 48:2 49:14,19 50:1	154:22 156:18 164:10 168:11 173:12 186:15 190:17,21 191:14 192:9 194:17 197:9 200:21 203:3 208:9,16 209:7 209:18,19 210:3,10,11 211:13 221:17	9:21,23 102:8 102:12 guarantee 214:18 215:9 guess 15:19 25:5 35:8 41:17 51:20 64:17 67:5 71:20 75:11 79:13 85:19,22 87:13 104:24 113:15 118:23 119:16 122:7,9 169:24 171:18 188:10 207:1	

277:3,8 285:8 285:12 286:4 298:11,17 299:2 308:1,7 308:17,19,20 309:14 310:3 323:14 324:15 324:21 325:1,5 325:12,14,16 325:20 350:2,4 350:13 354:16	handled 201:11 201:11 274:14 274:14 hands 30:9 321:14 354:19 happen 48:14 113:20 115:17 184:23 255:11 264:15 happened 74:16 192:20 193:1 224:13 225:7,16 293:6	heading 87:18 239:14 headquartered 89:16 headquarters 102:8,12 heads 119:11 health 64:6,11 64:14 127:11 128:2 135:19 136:1,12 140:7	heard 60:8 216:13 232:10 232:15 heat 47:18,21 held 2:12 9:10 72:16 92:21 166:20 167:4 Hello 30:9 80:11 help 11:12 12:16 15:24
half 237:1 hand 21:24 25:18 35:11,12 65:16,17,17 131:24,24 139:21 207:3 208:4 242:4 268:17 269:4 278:1 286:19 293:15 310:7 345:4 handbook 6:8 101:5 handed 26:6 65:24 101:3 200:14 201:11 282:2	happening 183:14 184:22 happens 183:12 happier 12:9 happy 144:23 harbaugh 78:11 hard 175:1 250:23 279:23 harder 183:4 haroon 4:6 10:1,24 haroon.anwar 4:12 hasty 130:4 havai 4:19 head 12:4,12 20:10 45:7 95:17 114:23	186:21 187:1,4 187:11,12,15 188:5 190:2,3 190:11,16 191:13,13,16 191:18 192:6,8 192:11,24 211:3 231:23 233:5,8,14,16 233:23 234:2 234:11 235:10 235:14,18,24 236:2,5,7 237:19,21,22 238:7 269:23 269:23 334:17 334:18 338:21 340:20 341:6	helpful 87:9 115:21 helps 129:22 198:10 264:17 hennet 5:12 76:7,19 77:2 83:5 hennet's 222:18 herbicides 74:21 hereof 360:11 herndon 2:17 9:11 herogeneous 110:12
handing 18:13 100:16 150:11 199:18 200:5 331:9 handle 275:9 275:12		healtheffects 6:12,15 8:24	

hesitant 69:24	348:9,15	histories 45:22	325:1,5,12,14
hetero 110:20	hill 93:13	history 6:20	325:17,21
heterogeneity 266:20	hindcasted	27:13 202:20	350:13
	231:18	204:21 211:4	hold 122:17
heterogenous 110:18,20	hindcasting	245:18,20	217:1 223:2
hhs 132:16	46:24 50:11	253:12 254:9	home 67:7
high 36:24	148:6,7,11	254:10,12,12	honest 167:19
47:16,20 60:3	151:5 229:18	254:16 255:3	honor 59:16
185:20 196:24	hired 75:13,14	260:8 263:5	60:4 61:9,12
279:4,5 280:9	222:12	272:17,24	honors 60:10
281:11,16,19	hiring 78:10	274:15,22	60:15 61:4,10
281:21 287:21	historical 6:24	276:6 277:1,7	61:18
289:22 307:6	7:5,18 8:2	hit 271:19	hope 66:24
328:10 329:12	50:12 97:9	holcomb 7:9,22	67:10 162:13
336:5 337:11	99:3 123:16,19	8:6 13:23 34:7	172:13 192:14
337:11	125:7 126:17	34:16,20 90:22	hotel 163:15
higher 63:17	127:4,18 133:7	91:1 93:9,12	hour 13:16
171:11 251:16	133:23 134:1,3	94:17 95:21	65:8,14 66:18
271:10,21	135:13 140:11	96:8 97:8,15	66:19 67:18
303:5,6 305:7	140:14,16,24	99:12 116:11	83:11
319:6,19 322:7	141:8 150:7	120:11,18	hourly 66:10
337:22	152:6 158:10	121:7 141:13	66:18 67:18
highest 60:10	158:20 159:6	146:2,18	hours 13:7
61:11,18	164:14,23	147:16 152:4	17:15 66:11,19
114:19	193:23 200:14	159:5 165:8	67:3,6 312:4
highlighted	200:20 206:15	200:22 205:11	housing 133:1
269:11 276:13	216:19 229:23	205:19 224:7	huge 342:4
282:18	255:4 256:18	250:5 260:23	human 52:11
highlights	258:1 273:11	277:4,8 285:8	103:16 113:19
36:21	275:10,14	285:12 286:4	127:6 134:14
highly 225:8	276:9 346:17	298:17 299:2	140:19 179:2
322:16 328:13	350:1	308:1,17,19,20	191:12,13,18
328:14,21	historically	309:14,14	192:24
	159:19 192:20	323:14 324:15	

humans 48:17 51:7	hydrogeology 38:12 55:6	345:6 identified 148:6,9 160:10 201:4	implementati... 214:22
hundred 31:7 237:5	246:11 353:6 357:4	identifies 321:19	implemented 104:14 115:18
hurt 137:23	hydrological 52:15	identify 332:1	implication 318:9 357:11
hydraulic 113:18,20 118:11,11,17 164:20 180:19 180:20 181:4 190:13 197:20 228:9 240:12 260:15 308:10 309:23 310:4 313:14	hydrologist 38:2 263:10	ignorant 212:22	implications 336:12
hydrochemical 191:2	hypothesis 106:15,24 169:24 171:18	ignored 129:23	implied 248:10 272:7,14 274:4 300:11 343:5
hydrogeologic 86:22 110:12 110:15 190:23 208:12 210:4 215:18 353:11	hypothetical 51:21 127:12 128:4 237:20	ignoring 279:7 349:18	implies 49:3 182:24 187:5 244:2
	i	illustrate 45:23	imply 123:18 123:24 233:23 245:5 250:18 309:19 329:13 338:11
	idea 67:2 80:22 81:24 83:9 145:15 160:5 315:17,22	illustrated 295:15	implying 104:21 164:21 248:7
	ideas 242:23	illustration 279:18	importance 142:23
	identical 140:4 309:20	image 291:12	important 40:6
	identification 18:11 21:22 25:16 35:15 65:19,21 100:20 132:3 139:24 150:14 157:1 166:11 200:8 242:7 268:20 278:6 286:22 293:18 310:10 331:12	immediate 285:15,17	70:5 130:3,3 205:9 216:12 263:6 280:12 281:5,6 287:21 310:5 354:21
		immediately 174:13 189:23 285:13,16	imposition 105:4
		impact 115:2,3 150:3 270:5 306:9 327:22 355:24	imprecise 337:19
		impacts 31:11 32:3 115:11,20	
		impartial 191:23	

impressed	181:6 275:5	339:12	334:8 352:11
218:7	including 79:1	index 5:1	induced 103:16
impression	164:20 278:21	indicate 268:5	industrial
56:16 59:2,24	inclusive 38:24	290:14 322:13	96:10 205:22
64:12 347:6	incomplete	indicated	277:15 325:11
improve	23:21 263:7	290:21 296:1	infant 132:18
136:11 321:22	272:24	296:10 311:2	infer 334:18
improvement	incorporate	321:21 322:6	inference 231:7
259:23,23	157:10	360:10	299:16
inaccuracies	incorporated	indicates 61:15	inferred 329:14
221:5 228:4,7	198:21	65:7 249:12	inferring
228:18	incorrect 22:22	256:9 258:3	270:10,15
inaccuracy	23:13	indicating	infinite 113:11
228:12	incorrectly	218:14 295:20	245:7
inaccurate	252:24	indication	influence 210:1
227:21,23	increase 184:11	322:3	211:16 213:19
254:7 337:5,9	304:24 314:9	individual	213:21,22
inappropriate	339:6,18	139:10 147:19	influenced
193:19	increased	175:3 274:7	150:8 190:15
include 34:12	67:18	291:17 292:22	191:11 192:5
36:16,17 37:1	increases	304:19 355:5	220:24
118:10 278:10	304:23 335:5,8	355:18	influences
278:14,19	increasing	individual's	110:13
288:20 300:17	113:6 301:2	355:10 356:15	inform 338:15
300:20	incredibly	individually	information
included 26:14	315:6	68:21 205:21	69:7 70:20
26:15 36:19	independence	individuals	84:12,18,20,23
45:23 128:10	257:7 293:10	51:1 79:1	88:5,9 128:6
129:22 140:4	independent	103:23 126:19	136:16 159:23
181:6 274:20	59:3 139:19	127:6 138:21	177:2 187:23
278:17 298:18	256:6,16,17,22	146:21 149:7	201:24 202:16
313:9 325:15	257:9,11 290:2	158:12,21	230:6 337:1
includes 36:10	290:3 291:24	160:2,11	351:14
62:21 132:23	292:14,17	209:22 237:12	

inherently 98:19	instructor 71:7 instructors 71:12	interesting 70:6,7 interests 62:11	invest 211:18 invited 76:24 102:19
initial 98:14,15 98:22 108:3,7 121:23 159:15 168:14 169:13 192:4 197:2,2 322:3 338:24	insubstantial 315:19 316:1 insufficient 334:23	intermittent 121:6 interpolate 112:12 interpretative 322:16 328:13 328:14,21	inviting 93:4 invoice 5:23 6:4 66:15 67:3,9 67:12,13
initially 94:23	integrated 119:7	interpretation 322:16 328:13 interruption 149:22	invoices 21:3 66:5
initials 49:6	intend 23:24 24:21 25:11	introduce 9:17	involve 31:13 31:19 105:9
innovative 121:18 123:1,9	28:3 29:7,12 67:4 343:3	introduced 70:18 98:21 125:4 325:20	involved 31:17 31:23 33:5
input 34:19 35:6 91:3,8 155:22 179:5 191:7,7 192:1 210:6,7 229:24 230:20 231:5 260:5 304:10	intended 13:8 137:13 138:9 138:20 139:8 146:20 147:18 234:16 247:19 334:2 337:1	introducing 266:4 267:12 introduction 29:22 103:9	46:13 48:2 49:20,21 50:3 51:16 63:22 64:23 71:11 99:19 245:18
inputs 188:7 331:2	intends 355:24	intend 29:15 357:6	involvement 72:20
instance 31:22 75:10 188:12 189:21 238:13	intentionally 20:2,3	interaction 116:5 152:14 152:17 155:1 157:24 222:24	involves 228:23
instances 146:15	interacted 76:17 80:11	intrusion 52:11	ion 302:4,19
instantaneous 198:15	interaction 30:18	invalid 264:11	irrelevant 158:17 193:19
instantly 266:7 267:15	interest 52:15 70:4 111:6	invalidate 7:15 242:14 252:20 252:23 253:5	island 102:10
institutes 58:17	interested 30:18	interest 254:6 264:11 264:24	isolate 317:15
instruct 137:19 143:11,20	85:20 213:23 214:1 347:22 361:16	invalidated 253:19 invalidating 253:7	isolation 47:8 49:1 50:9 53:4 54:8,11 237:17
			issue 67:12 70:5 96:21 128:2 149:8 165:14,23

175:11 207:12 220:23 247:2 256:21 307:14 314:12,18 315:8 316:7,8 316:17 322:9 334:1 issued 66:22 203:20 340:6 issues 57:19 89:20,23 90:2 91:14 92:12 144:6 209:6 217:6 311:3,7 311:8 312:9 340:13 item 60:16 326:16 328:9 items 37:14 60:17	jerry 93:23 jim 44:20,21,23 job 1:24 37:23 92:3 105:11 210:6 229:17 279:19 289:23 342:19 347:17 350:20 356:8 john 53:12,23 80:4,5 81:12 81:18 84:4,12 84:22 250:10 253:4 join 52:22,23 102:11,12 jones 27:7 28:14 29:2,13 29:19 30:14 32:6 252:6 journal 30:20 33:7 38:20 243:6 342:18 343:17 judge 144:14 judges 350:5 judgment 130:23 131:3 182:10 183:19 183:22 348:18 348:19 349:4 july 6:11 jump 110:7 130:20 150:23	jumping 128:15 185:2,6 278:8 justice 4:4 10:2 11:1,2 75:2 justice's 76:1 k kailey 4:7 10:6 kailey.silvers... 4:13 karl 243:18 kd 198:17,22 304:5,10,20 305:1,7,17 306:12 307:2,6 kdean 3:9 kds 197:24 keep 43:13 137:23 144:9 198:10 260:9 keeps 198:11 302:15 kevin 3:5 9:20 14:4 16:24 22:14 137:21 144:4 key 131:7,18,18 134:16 kind 16:1 48:17 51:14 80:12 102:7 109:1 113:2 157:23 176:18 177:20	178:5 196:9 211:6,19 221:16 254:3,5 279:11 282:22 304:9 320:17 339:11,13 344:19 351:23 knew 72:1 75:3 81:22 88:3 102:4,19 171:6 250:24 know 12:24 13:2,8 15:12 16:3,14 19:18 20:2,14 21:17 24:7,23 29:19 29:21,21 30:6 30:14,17 31:5 32:9,17 33:2 33:12,18 34:24 35:1,1,2 36:13 36:17 37:22 39:1 40:1,13 40:15 41:8,13 41:24 42:22 43:11,22,23 44:19 45:5,8 46:10,11 47:15 48:5,8,19,22 49:4 51:9 52:7 52:9,12 53:17 53:21 54:1,16 54:18,21,22 55:2,19 56:21
j j 3:15 j.c. 5:11 j.d. 242:10 january 5:13 5:14,17,21 6:6 22:10,20 26:6 26:10 39:1 65:10 66:23 67:4,9 jeffrey 4:20 27:7 28:14 29:14 33:2,12			

57:2,4,5,11,13	125:17 129:18	220:15,23	320:23 321:3,7
57:15,17,18,20	129:19 133:16	221:5,7 223:24	321:10,12,13
58:4,21 60:1	142:6 144:5	224:14 225:5,6	321:15 322:8
62:10 67:8	146:10 159:16	225:14,14,23	322:22,23
69:4,23 70:7	163:12,13	226:22 228:14	323:2 324:2
70:13,14 71:1	164:4 165:2	232:9,18	327:20 329:1
71:2 74:15,22	166:4 167:3	236:19 238:8	329:15 330:23
76:9,12,19,21	168:8 170:20	239:24 241:16	336:6,9 337:10
77:4,22 78:24	170:20 171:3,4	241:23,23	337:14,15,16
79:3,11,20,22	171:5,6,10	242:1 245:4,23	337:18,20
79:24 80:7,11	173:8,19 174:6	251:11,12,23	338:2,3 339:3
80:12,12,12,19	174:11,23	253:3,11,22	339:19,21
80:22,24 81:1	176:4 177:11	255:10,11	341:2,3 343:4
81:2,20,23	178:11,12	256:4,7,10,12	343:13 344:2,4
82:6,9,11,14,19	180:1 181:16	259:4,4 260:10	344:5,15,23
82:20,20 84:16	181:23 182:2,4	260:11,15	345:17 347:15
84:23,24 86:9	183:16,18	266:3,4 267:11	348:13 349:16
86:11,12 89:2	184:1 187:8,15	267:24 272:19	349:16 351:8
90:7 91:10,11	191:3,4 192:22	273:13,14	352:1,12,15
91:14,15 92:5	194:20 195:13	275:4,21	353:5 354:18
92:9,11 93:3,4	195:18,18	277:16,22	354:21 355:21
93:5,17 94:23	196:2,5 197:7	279:5,6,14,20	356:2 357:14
94:24 95:22,23	197:12 198:9	281:13,13,14	knowing
96:17,18,21	198:11,20	281:17,18	129:20 289:23
97:2 102:18,19	205:6,8 208:8	284:4,4 288:3	knowledge
102:23 103:22	209:9,10,23	292:17 293:2	36:6 37:12
104:1,24	211:2,5,6,12,17	297:1,4,4	75:19 83:1
105:20 108:8	211:19,22	300:2,9,20,22	88:6 94:11
108:23 109:3	212:23 213:13	302:11 304:10	121:10 136:12
109:11 112:7	213:15,23	304:15,16	165:10 204:1
112:19 114:15	215:21 216:4,6	305:4,5 312:2	212:1 260:17
118:6,16 119:7	216:8,11,12	312:21 315:9	273:4 319:5
120:8 123:8	217:2 218:6,22	316:4,6 317:17	339:5 353:9
124:20 125:5	218:23 220:6	320:11,20,20	

known 44:19 45:5 71:4 96:5 96:6,7 98:3 102:23 121:22 192:21 197:23 252:1,1 276:23 konikow 1:13 2:12 5:2,6,12 5:15,19,22 6:2 6:3,7,19 7:15 8:14,16,17 9:16 10:14,22 18:11,14 21:22 22:2 25:16,19 25:21 26:7 35:12,15 65:19 65:21 83:20 100:20 107:6 132:3 139:24 150:14 157:1 162:3,11 166:11 168:6 176:10,14 194:15 199:17 200:8 242:7 261:22 268:20 269:19 276:17 278:6 286:22 293:18 297:19 310:10,16 330:20 331:12 345:6 353:21 358:13 360:19	konrad 53:8 krauskopf 53:9 kyle 27:10 I I 6:22 labeled 201:9 332:12 laboratory 149:2 156:13 156:20 158:9 158:19 lack 113:15 164:10,13,18 164:21,23 193:23 200:13 203:7 205:5 206:5 216:19 lakewood 71:10 land 174:9,12 189:15,17 landfill 96:10 325:10 landowner 104:6 lands 73:23 language 140:4 large 112:18 119:10 203:1 231:20 232:22 257:5 292:21 292:21,24 296:15,17	297:2,3 314:5 larger 45:2 296:17 321:20 325:6,7 345:11 las 31:5,7,24 lasts 104:17 late 40:4 71:19 71:24 128:14 laugh 39:6 44:5 56:7 61:7 74:8 laura 3:15 9:22 14:4 16:24 law 11:17 74:15 lawrence 149:1 156:13,20 158:8,18 laws 104:14 lawyer 11:1 14:13 70:21 226:24 lawyers 14:1,2 14:10,12,14,16 14:19 15:6,24 17:24 21:6 22:20 66:5 67:12 75:3,11 83:24 162:19 199:24 200:3 232:11,15 262:2 layer 92:11 118:19 145:18 312:13 313:1,2	313:7,13,15 layperson 348:2,8 Ibaughman 3:19 lead 157:11 170:1 171:19 leadership 3:3 3:13 9:21,23 leaked 216:2 leaking 48:12 277:12,13 learned 350:18 leased 74:18 leaves 170:17 led 111:14 340:24 left 79:8 102:12 162:21 legal 223:12 226:20 227:3 legitimate 341:1 lejeune 1:7 5:24 6:5 7:2,10 7:23 8:7,23 9:12 11:2 19:6 21:11 30:22,24 39:8 62:23 67:23 70:2 72:6 85:10 87:18 92:21 97:1 99:14 100:2 116:10
--	---	---	---

116:15,19	134:13 135:16	224:12,23	295:20 296:3,8
121:11,12	140:18 152:10	225:8,19 226:7	304:16 317:20
126:22 132:21	165:13,22	226:17 232:1,1	318:9 359:3,5
136:3 140:11	168:12 183:23	232:9,10 233:7	359:7,9,11,13
152:3 164:10	202:9,17	233:7	359:15,17,19
164:16,24	204:18,23	limit 113:8	359:21,23
165:1,14,23	234:12 271:11	137:22 144:8	lines 231:9
175:6 186:20	279:13 294:14	limitations	285:2
191:17 200:23	296:20 334:8,9	104:12,18	linkage 81:23
215:20 240:20	334:10,14	111:23 330:1	119:5,14
250:12 308:8	335:6 337:15	346:15	linked 82:16
343:21 345:10	351:22	limited 134:1	119:4 130:5
345:12 347:21	levels 96:24	140:13 155:22	256:19
lenny 284:4	97:9,10,20	168:7,18 184:4	liquid 48:15
leonard 1:13	113:21 123:11	194:19 288:17	175:24
2:12 5:2,12,15	126:3,18 127:5	289:2 311:3	list 5:16 25:21
5:19,22 6:3,19	127:22 136:18	329:23	26:9,15 36:10
8:14 9:15	143:7 145:8	limits 195:16	37:10 61:3,13
10:14 26:7	158:21 160:11	260:10	90:7 120:22
162:3 360:19	165:7 241:18	line 23:2 33:4	203:23
lessons 8:13	272:3 295:14	43:13 91:15	listed 26:3 41:6
293:24	334:15,17	103:10 106:12	41:8,9 43:12
letter 8:15,19	336:1 337:3	108:13 109:22	61:10 99:16
310:18 311:10	338:12 346:18	109:22 110:19	154:20 252:5
311:11	license 128:12	121:15 168:3	312:5
letters 19:4	lie 167:23	176:9 194:11	listen 28:7,12
20:6,23	life 12:5 127:7	231:10 238:14	40:11
level 43:1 47:16	127:8	240:7 265:17	lists 71:22
47:20 63:14,15	light 236:18	265:18 266:15	liter 135:17,18
63:17,19 88:2	354:9	269:11,13	337:21
98:3 99:4	likelihood	276:13 282:19	literal 254:6
114:19 119:19	225:7	283:4 287:19	literature
123:12 125:11	likely 41:4,6	289:19 290:10	210:11 316:8
125:17 126:4	48:7,8,11	294:16 295:17	316:10

litigating	living	longer	345:16 347:23
226:21	48:18 51:8 127:15	104:17 217:1 275:4	looking 34:23
litigation	llc	longley	39:17 42:12
1:7 9:13 11:3 19:7	3:4	27:10	46:23,24 51:18
21:1,13 24:22	load	look	51:20 54:20
68:1 69:10,20	267:7	16:4 23:1	96:7 116:4
72:21 73:9	loading	26:2 42:6	121:14 138:1
139:9,14	171:5	53:22 54:22	176:8 178:8
147:18 148:2	172:20 176:6	71:22 111:19	186:1,3 194:1
219:4 221:22	188:15,18	116:2 150:21	194:22 195:8
222:13 226:9	189:23 190:13	170:24 178:13	238:14 262:10
226:13	190:24 267:4	183:15 198:16	284:13 292:13
little	270:4 276:20	210:3 213:8	321:9 322:23
39:11	277:2,7 321:21	218:19 220:2	347:22
54:20 61:22	322:4,7,13	221:2 241:10	looks 18:17
80:15 110:8	323:7 324:19	252:11,14	38:18 39:13
112:2,3 123:23	location	283:15,17	42:13 47:7
130:21 160:17	96:5	285:21 291:17	68:8,15 69:9
163:12 194:23	179:24 276:23	300:19 308:10	69:15 179:9
195:9,12,24	281:5,6,12	309:23 352:17	278:16 292:23
208:3 209:14	288:5 289:18	looked	326:8
218:7 220:15	291:16 293:5	15:8,11	loss 300:11,21
228:17 242:17	293:11 317:4	16:8,15 28:10	losses 298:19
251:16,17	locations	35:1,2 41:1	299:3,9,15,17
273:19 277:10	122:3	42:9 46:10	299:19,22
281:20 288:2	281:11 288:21	48:22 52:11,16	300:7,15
301:10 302:13	291:10	90:7 93:15	lost 262:18
306:7 323:1	logical	101:10 128:18	330:7
324:3,4 332:4	98:21	163:8 216:16	lot 31:10 47:18
334:5 336:18	277:18	218:5,17,23	58:23 73:18
livermore	long	219:2,2,11	91:13 238:5
149:2 156:13	17:13,13	221:12 252:10	282:23 284:8
156:20 158:9	77:17 102:9,10	294:23 312:4	329:8 350:18
158:19	152:22 160:20	317:10 319:11	350:19 353:8
	348:21 349:6	320:23 339:20	
		341:3,16	

lots	257:24 320:16	262:18,18 264:2 273:10	258:9 273:23 276:7 284:5	maps	308:11
low	281:16,20 293:2 306:13	276:14 311:22 311:23 326:9	285:18 306:20 314:16 334:24	march	6:14 7:2 8:19 88:12 166:21 361:23
307:3,6 313:1	336:5 337:12	341:22 345:22	351:21 356:2,4	marine	7:10,23 8:7 94:2,2 132:20 140:10 200:23
337:12		magnitude	makes	mark	100:16 156:23 166:8,9
lower	65:11 171:12 248:16	207:13 296:16 297:3	344:21 51:1 124:21	marked	18:10 18:14 21:21 22:1 25:15
251:17 273:19	273:22 305:7	mail	144:9 155:9 156:8 188:7		35:12,14 65:18 65:20 66:1 100:17,19 101:4 132:2
319:20 334:15	337:22	mails	man	management	150:13 156:24 166:10 200:6,7 242:6 268:19
lump	312:22	19:3,23 20:6,23 69:14	30:19 104:6	managing	139:23 150:11
lumped	290:1 313:1	main	104:20,21 123:21 124:1,4	mandates	150:13 100:17,19
lumping	312:11,20	62:11 93:11 123:17	105:1,1,8,9,16 124:5 148:15		166:10 200:6,7 242:6 268:19
lunch	160:19 162:13,14,17	maintain	106:20,21 124:5 148:15	marking	101:4 132:2 139:23 150:11
162:22		maintained	107:4 127:21 128:1		150:13 156:24 166:10 200:6,7 242:6 268:19
luncheon	161:8	major	108:20,21 127:21 128:1	managing	278:5 286:21
lunchtime	17:16	313:19 314:1	128:20,21 130:20,21 131:1	mandates	293:15,17
luxenberg	3:14	320:2,5 325:23	131:20 132:1		310:9 331:11
m		326:16 328:8	133:20 134:1	marking	345:5
made	52:5,12 59:6 86:17	majority	135:20 136:1		25:19
121:22 125:1	127:11 194:16	332:23	137:20 138:1	marriott	132:1 139:22
207:8 208:17	209:17 218:5,8	make	139:20 140:1		242:4 268:17
230:15 253:22		12:5,8 61:6 167:24	141:20 142:1	manuscript	278:3 286:20
		171:2,8 195:13	143:20 144:1		310:7 331:9
		197:10 210:23	145:20 146:1	map	2:15
		211:7,14 213:3	148:20 149:1	mapped	9:10
		216:2 221:3	151:20 152:1		mary 93:13
		253:16 254:23			

mask 184:21	290:11 301:4	mcl 63:9,12,17	233:4,19
maslia 4:21	matched	63:23 64:2,11	235:21 245:15
8:16 14:2,11	254:16 255:3	64:13,20,23	246:9 248:22
14:12,17,20	matches 255:17	135:16 271:19	251:5,10
15:7,24 17:24	256:3	mcls 64:6 65:3	254:13 259:16
26:19 69:15	matching 6:20	mdl7172979	259:18 260:4
70:17 71:3	245:18,21	1:24	261:1,1 267:19
72:5,8,17,23	254:9,10 260:8	mean 14:24	275:11 277:20
89:6 186:12	339:21	15:11,13 17:10	277:22 285:16
265:23 271:3	material	24:5,8 34:12	285:18 289:13
272:2 310:19	111:14 313:7	34:22 52:2	290:9 301:1
310:20 342:16	313:14	62:8 72:13	304:2 309:7,22
maslia's 186:18	materials 5:16	75:3,5 82:14	311:23 312:19
mass 108:16,21	25:22 26:9,14	95:22 103:19	314:20 315:8
109:5,7,12	55:4 252:5	103:21 108:21	319:17 324:10
170:17 171:5	math 348:12	109:6 113:3	327:13 334:14
172:20 176:6	mathematical	123:18,24	337:9 338:9,20
188:14,18,24	43:19 107:15	124:2,3 125:16	346:24 354:4
189:2,4,23	107:23 130:7	127:9 135:19	355:4,9,18
190:12,24	208:12 241:1	157:19 164:19	356:14,18
267:4 270:4	mathematically	170:10 175:23	meaning 106:7
276:18,20	183:9	178:7,18 180:7	243:14 298:22
277:1,7 321:20	mathematics	182:19 184:13	357:6
322:4,7,13,14	212:3	187:3,8,11,20	means 109:11
323:7 324:19	matt 82:23	193:12,14	125:19 187:17
328:6,11,12,21	matter 9:12	194:20 195:4,7	195:12 225:2,5
329:7,22 330:2	337:2,4 360:6	195:19 205:1	226:19 254:14
338:2 354:23	maximum	206:8 214:11	281:15 302:6
masses 109:1	63:14 135:16	215:3,11,13	316:14 328:20
match 253:12	135:18 214:23	217:6 219:7	meant 120:5
254:12 255:16	mc 63:9	222:2,5 223:9	126:1 154:24
258:1 259:13	mcdonald	225:1,3 227:22	178:9,19
263:5 280:1,2	78:11	228:8 231:22	179:20,23
281:3,12		231:23 232:14	180:2,4 185:18

186:8 206:12 208:4 223:20 226:1 232:19 233:22 267:22 270:15 329:3,4 354:1 measure 184:16 228:15 259:21 measured 334:12 336:22 measurement 228:10,16,16 measurements 124:22 159:10 240:3 measures 259:19 261:6 measuring 261:2 mechanisms 158:4 media 241:2 mediates 176:18 177:20 178:5 medical 341:6 356:14 medicine 58:13 58:19 medium 336:6 meet 14:1 29:24 235:6 274:12	meeting 7:17 8:1 14:9,10,23 15:4,5,6 16:7 16:20,23,23 17:8,14 29:23 30:4,5 32:20 33:24 40:16 72:15,17 80:10 86:5 87:8 166:19,19 167:3 meetings 14:3 17:18,23 30:2 32:15,21,23,24 33:8,9,12,23 76:15 80:8 86:10,17 member 40:2 55:15 59:14 61:16 340:2 344:9,17 347:21 members 41:10 44:13,13 53:4 59:12,13 87:2 90:5,8 92:17 95:5 214:10 341:4 342:7 344:14,19 membership 60:2,8 341:3 memory 42:10 mention 139:14 185:12 224:23	340:22 mentioned 34:2 41:17 45:11 49:14 54:5 57:23 67:17 70:23 73:11 89:6 90:16 91:2 101:17 105:13 148:2 149:17 163:3 175:11 237:16 282:22 299:24 339:9 mercer 44:20 44:23 merit 2:22 mesa 294:15 messages 19:4 met 14:4 29:20 32:10,11,16 33:3,21,22,23 71:16,18 76:22 80:7 87:3 89:10 201:21 201:24 203:18 203:21,22 221:16 338:8 343:15 meta 334:21 method 131:11 180:24 207:19 215:5 217:14 217:14,20 218:13 220:8	228:15 244:22 260:12 275:17 314:3,13 315:15 316:21 318:17 methodologies 357:19 methodology 64:2,24 246:13 247:18 251:4 methods 7:5 102:22 111:21 134:10 200:19 202:8 207:23 214:9,14 215:5 217:22 218:3 238:16,22 240:11 241:12 241:16 245:14 273:15 277:21 315:18,24 323:20 357:22 mexico 47:12 mic 85:24 95:9 95:12 149:14 micrograms 135:18 337:21 mid 122:1 128:13 163:10 229:22 middle 194:10 202:3 251:18 269:10 279:16 282:19 305:22
---	--	---	--

305:23 306:6	249:9	119:2,3,7,9,15	164:19 168:8
313:2 326:4	misleads 244:4	119:17,18,24	168:11,19
332:11 337:12	247:16	120:3,6,7,19,22	169:21 170:14
337:13	mispronounce	120:23 121:5	170:15 177:6
migrated 73:22	182:18	121:19,20	177:11 179:11
mike 94:13	misremember...	123:2,8,21	180:14,15,15
miles 31:7	306:5	124:2 125:2	180:16 181:3,5
milligrams	missing 229:22	127:21 128:1	181:7,14,20,20
135:17	274:15	128:22 129:4,6	181:21,22,24
mind 46:7	mission 192:11	129:16,20,21	182:5,7,24
146:3,11	misspoke 82:3	130:6,8 131:5	183:1,3,5,7,7,9
191:21	125:24	131:6,10,21	183:12,17
mine 129:11	misstates	132:7 133:6	184:10,11,12
246:24	122:19	134:7 135:11	189:5 190:10
minimal 355:24	misunderstan...	136:17 137:13	190:14,22
minimize 153:4	210:17 303:6	138:17,19,19	191:6,6 193:15
minimizing	mixing 298:1	139:8 141:13	196:4 197:4,6
261:8	298:11 339:8	141:19 142:5	198:10 199:1
minimum	339:22	142:24,24	205:9,10,17
330:2	model 8:13	143:1,4 145:3	206:22 207:19
minor 275:7	13:22 16:11,11	145:3,6,6,7,14	208:9,9,9,17
minority 342:9	34:5,20,21	145:15,19,20	209:18,19
minute 297:8	43:20 46:16,16	145:21,24	210:1,2,5,8,9
minutes 160:21	46:17,19 50:17	146:4,12,18,20	210:11,13,16
339:9	74:2 92:10,11	147:17 148:15	210:19,20,23
miscalculations	98:10,16 106:5	149:9,10 150:1	211:1,11,13
157:12	106:13,15,19	150:4,7 151:9	212:7,10,12,16
mischaracteri...	106:23 107:19	153:9,13	212:18,19,23
141:15 236:9	107:20 109:7	154:19 155:3,4	213:3,18 214:4
246:19	109:24 112:13	155:22 158:1	217:9,21,21
misinterpret	112:14 115:4,7	158:14,15,16	224:17 227:20
248:21	115:8,12,12,19	158:17,19,22	228:2,21 229:3
misleading	115:22 116:22	158:23 159:13	229:9,10,18
244:8 246:15	117:8,12 119:1	159:19,23	230:5 231:6,21

232:23 234:18	271:7,15	338:17,21	90:17,18,23,24
234:20,24,24	273:20 274:14	339:7,9,15,19	91:4,20 92:22
235:1,3,7	275:8 276:21	339:22 342:11	94:10,17 95:21
237:2 238:9	279:4,18 280:1	342:14 343:3	97:6 99:13
239:15 243:22	280:6,17,24	347:5 348:20	101:20 102:21
243:24 244:14	281:1,8,13,18	349:5 351:1,3	102:24 113:23
244:15 245:6,7	283:6 284:13	351:9,12,14,23	114:6 116:15
245:10,12,21	284:15 285:8	352:7,9,10	116:19 120:11
246:14 247:12	285:12,20	355:12,20	125:21 127:3,9
247:14,23	286:4 287:2,10	356:1,3,6,8,10	127:13 131:7
248:8,16,20,24	287:14 288:13	356:10 357:12	131:19 134:2
249:1,6,10,15	288:14 289:4	357:13	134:11 140:15
250:13,17,19	289:11,23	modeled 158:3	148:14,17,23
250:22 251:3	290:5 293:24	modeler 183:4	158:8 164:15
251:20 252:22	294:21 295:21	209:7,7 224:2	164:24 170:2
253:5,11,14,15	296:1,11 297:1	234:18 235:16	176:19 177:8
253:19,20	298:1,12,15	236:16 341:10	177:21 178:6,9
254:1,5,14,15	299:1,2 300:19	modelers 246:2	179:11 180:2
254:15,17,22	300:21,24	246:8	180:10 184:2
254:22 255:2,3	304:8,9 305:6	modeling 6:16	186:20 187:8
255:6,6,10,15	305:10 306:14	18:2 31:14,17	187:22 190:17
255:19 257:16	307:4,8,24	31:20,23 34:4	191:14,17
257:18,18,21	308:1 312:12	34:6 38:5,7,9	192:9 194:17
258:5,13,24	312:19 313:2,9	42:14,17,19,21	194:18 195:11
259:10,12	315:5,21 316:2	43:5,17,19	198:8 206:22
260:2,4,4,20,24	316:4 321:22	44:14 45:13,17	207:8,12
261:2 262:6,9	322:5 323:13	45:21 46:13	209:24 214:9
262:20,24	323:14,15,24	48:3 49:14,15	214:14 215:5
263:6,7,18	324:3,11,16	49:19,20 50:10	216:12 224:20
264:3,3,4,6,7,8	325:6,11,13,15	50:17,22 52:10	231:3 233:18
264:11,12,18	325:15 330:3	62:2,3 68:4	237:24 238:4
264:19,19,21	331:2,21 333:6	70:8,8 71:14	248:1 258:22
264:21,23,24	336:24 337:4	79:13 81:9,10	316:18 325:21
265:15 266:2	337:23 338:1,2	85:11 87:17,21	331:17 334:2

339:10 340:6 340:16,22,23 341:15,20 342:23 346:5 346:11 350:21 350:21 356:22 357:4 models 7:14 34:15 43:2,9 43:21 45:24 47:2 88:6 93:9 98:13 105:24 107:14,15 108:15 114:11 114:12,18 116:8,20 117:17,20,23 119:19 121:10 121:17 122:9 122:10 123:1,4 124:12,12 125:10 126:2,9 126:15,16,24 133:17,18 143:5 146:2 148:6,7,9,16 150:2,6 152:5 152:5 153:10 153:14 154:21 154:22 172:14 173:13 179:1,3 179:5 193:10 203:3 205:14 210:3,10 224:6	229:23 230:19 231:6,6,17,18 233:13,21 234:2,17 235:18 236:22 237:7,8,8,18 238:1,23,24 239:16 240:11 240:12,20,24 241:15 242:14 244:3,17,24 245:16 247:16 247:17 249:21 250:8,11 251:7 255:23 258:8 262:19 263:4,9 263:13 266:12 266:20 276:3,6 297:23 298:18 298:24 299:14 300:14,17 301:4 311:4 323:18,21 324:13 325:9 338:19 343:7 343:10 346:16 349:20 351:7 352:4 353:11 354:2,11 moderately modflow 78:3,6 117:8,24 119:1 119:17,17	120:4,18,21 214:21 324:12 modification 111:15 moment 46:9 54:3 122:8 188:15 momentum 108:16,21 109:7 money 211:19 monitoring 154:3 319:24 320:3,8 321:16 month 175:22 189:12 218:24 273:17,18,22 315:4 monthly 97:10 125:11 126:3 136:17 137:11 143:6 185:17 214:2,2,10 224:5 231:22 231:22 233:4 233:19 237:11 273:15 280:1 334:16 346:11 346:19 354:5 355:4,9,18 356:14,18 months 36:5 morning 9:4,19 10:22,23	355:22 morris 4:21 8:16 14:2 26:18 69:15 70:17 71:2,14 85:19,22 86:20 89:6 93:3 310:19 342:16 mothers 136:10 motley 3:4 motleyrice.com 3:9 mountain 6:18 73:19 74:12,18 75:6 148:18,22 149:4,18 150:17,20 151:6,9 152:15 154:24 155:3 162:23 move 48:16 143:17 192:17 285:5 moved 102:9 102:11,15 movement 6:16 115:23 153:2 197:9 241:2 moves 124:23 303:2 moving 176:4 251:19 302:12 302:15,17
---	--	--	--

mt 3:7	narrowly	nearly 272:3	negligible
mt3d 119:9,13 119:13,14,18 119:24 207:19 214:21 217:8 324:12 325:9 325:11 339:10	154:24 national 26:8 30:3 33:6 39:15 40:7,20 40:21 56:2,8 56:10,14,17,19	15:11 119:6 183:24 246:8 277:13 304:24 309:22 necessary	218:13 300:12 neither 109:2 298:16 299:1 306:13 361:13 361:15 net 302:6,6,8,9 302:18,21
mt3dms 117:12 119:2 120:24	56:19 57:24 58:1,1,5,7,11 58:11,12,18,18 59:5,15,23	105:4 necessity 198:9 need 12:22 13:7 36:8 95:9,11	network 298:7 nevada 31:4,8 31:10 never 33:21 67:7 72:13
muddy 155:10	60:2,9,18,22 61:1,1,16 71:9	108:3 118:9,20 176:18 177:1,2	113:10 123:20
multiple 96:9 104:1 215:21 274:10 277:10 277:17	80:9 149:2 156:13,20 158:9,19 340:2	177:20 178:5 182:2 183:22 184:15 188:10	148:10 222:11 228:13 244:15
multitude	340:4,5 341:19 344:8	192:22,24 213:16,17	244:16,16 248:11 249:10
183:10 205:24	natural 103:15	214:19 307:21 308:16 309:4	252:1 254:5,21 255:9,10 256:6
mustafa 28:8 29:13 32:9 271:4	159:3	356:3	256:13,17 274:4 317:22
n	naturally	needed 133:23	nevertheless
n 9:1 46:5	337:19	140:12 141:1,9	241:10 279:24
nae 5:16,19 61:13	nature 45:15	143:15 153:3	new 3:17 47:12
name 9:5 10:24 49:6 55:11 61:14 70:24 80:7 94:1,4,15 243:3,6 269:11 276:13 282:18	108:6 129:5,15 129:18 212:11 291:7 323:5	177:7 231:2 275:22	102:10 115:1 180:24 181:20
named 53:8,19 53:20 101:23	navy 275:1	needs 23:17	newer 120:20
names 54:2 93:15	331:16 332:12 332:18 334:4	115:8,10 174:15 182:6	nice 283:19 347:17
	navy's 8:19 331:20	192:21 235:6 240:1	night 19:11 66:3 68:8,15
	nc 7:2	negative	69:9,14 84:10 310:13
	near 47:12	260:14 296:22	

nods	12:4,12	203:5 206:3	313:20 314:1	object	19:17
non	14:16,19	216:22 222:20	314:22,22		24:2 28:20
	144:7 274:2	notes	315:14 316:23		54:15 57:9
	288:22	notice	317:21 319:22		59:8,17 78:23
nonaqueous		18:19 24:5	321:18 332:7		79:17 80:17
	175:24	noticed	333:10		82:7 97:12
nongovernm...	58:23	84:9	numbers		99:5 112:21
nonlinear		noting	170:15 325:4		114:2 117:21
	198:14	november	numeral		122:18 123:13
nonuniqueness		269:20	132:10 140:3		125:14 126:5
	258:17,22	nrc	numerical		126:20 133:10
nope	129:14	39:20 41:14	92:10 98:12		133:13 136:21
	227:4	42:13 43:16	131:10 152:16		137:15 138:6
normal	94:24	47:7 50:14,21	182:12 207:20		138:11,22
	274:9,11,19	55:24 56:3,6	217:8,16,22		139:11 141:3
	275:5,7 311:14	57:7 341:14	218:2,14 220:3		141:14 142:1
normally	247:5	342:9,14 344:9	220:9,24 221:8		143:8,24 145:9
norman	27:7	344:13 345:11	nuclear		146:6,22 147:7
	28:14 29:13,19	55:3	241:12 257:23		147:20 160:3
	30:14 32:6	56:4	313:10 314:4,8		160:12 166:1
north	1:2 7:11	number	314:13 315:19		168:24 173:2
	7:24 8:8 9:14	5:8	316:1,5,9,12,15		179:14 186:22
	31:7 73:23	13:20 19:15	324:5,6 338:4		187:13,24
	116:10 132:21	20:22 21:2	numerically		190:6 191:19
	140:11 200:24	26:2 67:3	217:12		192:12 196:19
notary	2:22	86:11 113:11	numerous		223:11 224:9
	361:4,21,24	122:2 153:15	205:22 207:5,6		225:22 228:19
note	136:23	153:20 154:2,6	208:6 262:21		234:21 237:13
	243:9 280:10	206:18 215:16	ny		246:16 249:2,7
	287:20,23	216:16 221:1,1	3:17		249:22 251:8
	322:12	221:14,15	o		253:1 258:18
noted	10:9	222:20 262:20	oath		258:20 263:20
	144:5 202:16	262:21 288:18	11:16		270:7 273:2
		289:2 290:5	360:13		286:7 287:16
		300:14 309:24			
		312:10 313:19			

288:15 292:2	216:1 240:2	obviously	oh 15:2 53:23
299:20 303:16	256:8 279:12	183:6 340:23	54:10 80:5
303:21 309:2	279:14	occ 23:7	110:20 120:1
318:7 323:17	observe 111:24	occasion 33:4	142:15 163:17
328:24 335:13	113:1,4	occasionally	218:9 239:11
335:19 337:7	observed 96:23	16:3 30:6	ohio 44:18 46:5
348:5 349:12	97:20,24 98:2	37:22 73:5	46:13,19
351:17 355:15	99:3 122:2	76:16 343:15	okay 11:4,7,10
356:20	123:11 152:9	occur 300:7	11:18 12:1,7
objection 19:19	165:6 205:5	306:10 334:18	12:15,20,21
67:15 114:9	255:16,18,21	occurred 84:7	13:2,6,15,17
117:18 144:4	255:23 259:13	occurring	14:16 15:15
165:17 173:6	279:21 282:24	132:23	16:6 17:2,22
174:24 219:5	287:8 289:19	october 6:1	18:5,9,18,23
221:23 236:8	289:21 290:8	66:9,10 69:11	21:10,19 22:6
284:16 295:1	290:16 293:7	72:21	22:19 25:14
333:7 346:22	294:14,17	offer 24:1,22	26:1,5,12,17,21
350:9 352:13	295:5,14,18	25:1,11 28:3	27:6 28:2,7,12
objections	296:2,19,21,21	29:8,12 164:5	29:6 31:18
144:6,9	301:7 317:3,24	360:12	32:5,11 33:11
objective	339:20,23	offered 193:21	35:24 36:12,15
123:15,15,18	observer 179:8	239:16 331:16	38:3,15 39:10
124:4 183:21	obstacle 283:6	offering 227:2	39:17 41:2
191:24 261:8	284:14 285:19	233:24 250:6	44:12 47:2,5
obligation	286:3	office 75:4	51:18 52:21
173:10	obtain 133:7	82:12 89:17	53:1 56:5,11
observation	134:1 140:13	102:5,7,10,16	56:15 57:23
113:12 124:11	346:17	offices 81:24	60:22 61:13,21
171:3 213:4	obtained	89:14,22	62:5,12 63:8
289:2 291:5	216:21 350:7	official 37:22	64:1,5,10,22
observations	obvious 62:13	officials 43:1	65:2,6,12,15
96:19 121:22	130:2 205:9	offs 131:4	66:8,15,22
124:14,22	227:24	offset 307:13	67:2,11,14
125:1 215:15			68:20 69:7,13

69:18 70:9,20	135:5,22	201:14,22	298:10,24
70:22 71:2,17	138:15 139:6	202:2,7,12,24	299:24 301:9
72:4 75:22	139:17 140:23	203:12,19	301:23 302:1
76:9 77:1,6,10	141:12 142:19	204:13,16	303:4,11 305:9
77:24 78:7,21	143:4 144:3	206:21 212:4	305:21 306:4
80:2 81:21	145:22 146:14	213:12,12	308:24 309:11
82:2,13,16	147:15 148:5	215:3 216:15	309:21 310:6
83:3,20,23	148:12 149:21	218:10,11	310:18,23
84:3,21,24	150:10,20	222:20 223:19	313:17,18
85:3,7,13	151:1,2,15,23	224:4 226:10	316:23 321:4
88:18 90:11	152:9,13,19	227:16 230:10	321:18 326:3
91:22 92:20,24	153:11,15	231:14 232:17	328:3 330:5,8
93:6 94:9,16	155:11,20	238:11 239:4,8	330:8,19,21
95:19 96:14	156:6,11,22	240:19 242:3	331:8,8,20,24
97:6 100:1,15	160:15 161:1	243:3 245:4	332:15 333:15
101:12,17,22	162:15,17,21	251:2 252:4	333:22 339:24
103:7 106:2,19	163:19 164:3	261:10,22	341:12 344:12
106:23 107:12	165:12 166:7	262:1,4 263:16	344:15,21
107:18 108:20	166:17,24	263:24 264:5	345:3,19 346:2
108:22 109:10	167:5,8,22	265:1,10,12,13	349:23 352:7
110:7,22 111:1	168:2,8,10,14	266:16,16	352:21 353:15
112:17 113:23	168:17,22	267:21 268:16	355:3 356:4,24
115:21 116:4	171:23 172:17	270:19 271:2	357:2,8,24
117:7 120:5,10	173:7,19	271:24 274:13	358:7
120:14,23	174:18 176:6	276:16 277:24	older 184:2
121:9,14	176:13 178:14	281:7 282:9,12	once 29:20
122:24 125:24	178:24 180:5	282:18 283:9	30:13 222:7
126:14 127:1	183:2 184:9,24	285:1,5,24	244:19
127:20 128:15	186:2 187:18	286:3,13	ones 16:14
128:21 129:9	188:5,22	290:20 291:20	50:15 72:5
129:12,15	189:18 193:3	291:20 292:6	87:12 221:11
130:11,17	194:9 199:19	293:14 294:5,9	265:7,8 271:7
131:2,14,17,23	199:24 200:5	294:20 297:6	274:12 312:3
132:9 134:22	200:18 201:7	297:19,22	

ooh	78:4	280:19,20,23	organizations	overestimates
open	52:7	281:7 305:23	58:10	281:24
opened	188:20	307:13,16,16	original	overlapped
opening	103:10	341:18 343:24	222:19	102:5
operated	48:9 74:19	353:1 354:3,15	252:6,21 327:16	overlooked
operates	106:16,24 114:24	opinions 23:24 24:7,15,21 25:10,23 27:19 28:16 29:3,8	49:2 242:18,20 oscillations 220:2	130:4 overlying 48:13 overpredicted 290:16,22
operating	175:15 272:20	29:12 35:5 83:4 86:7	outcome 172:9 173:22 175:19 176:15 177:16	overpredicting 287:14 288:14
operation	49:8 152:1 274:2,18 274:19 275:5	163:21 164:6 223:2,20 224:3 227:3 301:17	191:12 312:7 346:10 361:17	overprediction 291:8
operational	49:4,9 128:12	331:22 341:12	output 120:4	overpredicts 288:13
operations	151:10	opportunity 94:7 211:22	142:7 148:15 150:9 251:5	overriding 49:18
opined	239:17	opposed 291:12 355:10,19	352:3	overseeing 104:8
opining	224:4	356:16	outside 28:4 29:6,10 31:24	oversight 20:12
opinion	24:13 24:16 25:1 65:8 78:21 79:4 83:5 105:1 164:2,12 164:22 185:12 185:22,24 193:21 229:16 230:19 233:12 233:24 235:13 235:16 239:16 240:19 244:24 250:6,15,16 257:16 280:5	optimization 271:5 order 43:22 67:6 86:15 118:9 153:3 189:16 237:1 308:4 321:22 334:10,13 338:10 344:7 organic 132:19 140:8 147:12	32:21,23 33:11 35:3 67:23 71:10 179:8 332:24 333:1 overall 49:21 92:14 205:17 207:3 244:20 291:4 318:22 overdeveloped 104:13 overestimate 281:9 306:11	overstated 164:13 281:23 overstates 164:9,18 overstating 193:22 overused 106:6 own 27:21 28:18 44:24 79:9 217:2 244:2 246:15
		organization 57:8 58:23	overestimated 306:19,24	

p	276:12 278:9 278:10 282:12 285:2,16 287:4 287:5,5 294:6 305:19,22 306:7 315:1 316:23,24 319:22 321:18 326:1,4,4 328:4 330:6 332:1,2,11 333:15,17,18 333:19 346:1 359:3,5,7,9,11 359:13,15,17 359:19,21,23 pages 36:14 132:10 169:5 178:12 270:13 284:18 286:16 paid 21:4 65:7 67:23 panel 6:24 7:4 7:17 8:1 32:18 39:20 40:2,8 43:16 85:10,13 85:17 86:3,16 87:18 88:11 90:5,6,10,14,17 91:16,19,23 92:17,21 93:1 93:7,14,14,18 93:20,24 94:14 94:18 95:5	166:14,19 167:18,19,23 175:7,7 176:24 179:9 194:12 200:14,19 201:3,4,10,17 201:20 202:1,4 202:6 203:17 203:17,21 204:10 214:9 216:18,24 218:17 222:7 222:11 265:6 265:14 268:23 282:5 284:11 285:11 311:22 342:7,9,14 350:14 panels 20:8 32:13 39:14 50:15 68:4,16 68:22 70:3 76:15 99:10 100:6,13 167:10 219:19 299:6 papadopoulos 45:4 76:13,17 77:12,20 78:19 78:22 79:2,14 81:13,15,19 82:4,15,24 paper 245:5 250:9 357:15	papers 353:7 paragraph 107:13 108:14 109:23,23 110:8 111:2 116:5 130:22 133:22 135:1 151:4 155:17 155:18,19 164:8 168:15 169:19 171:16 172:6 173:21 206:2 227:16 229:14 239:14 243:11,19 247:10 290:13 295:12 305:23 305:23 330:5,6 333:23 346:3 348:18 349:23 parameter 34:23 35:5 43:20 80:13 91:11 118:22 193:13 197:22 205:10 211:14 213:20 228:3 258:6,8 261:5 304:16,17 305:4 307:18 307:22 309:12 309:13 310:5 318:10,12,14 318:17,18
----------	---	--	--

319:2 331:1,3	274:18 284:5,5	passage 188:23	302:2 318:1
parameters	289:16 290:7	passed 51:11	322:14 326:18
34:19 108:6,10	313:18 321:16	74:15 84:11,17	327:9 328:10
118:7 181:4	339:16	passing 63:9	328:12,20
184:15,17	partain 94:13	past 5:21 13:21	329:7,22
191:7 192:2,4	partial 98:11	20:9 37:7,11	332:21 334:13
193:4,9,14	participants	121:21 123:10	334:19 336:22
210:5 224:17	10:9 95:17	126:2 136:1	346:18,18
245:8,19	participate	151:17 231:24	peak 207:22
248:18 255:16	100:12 179:9	233:6,14	peclet 221:1,14
255:16 257:22	participated	262:22 340:4	314:22
258:10,13	93:24 167:9	paths 30:6,12	peer 5:23 6:4
259:1,2,9,11,20	participation	pathway 48:7	6:23 32:13
259:22 260:3,5	53:18 68:16,21	pathways 48:9	76:15 91:16,18
260:8,13,21	particular	patience	166:19 167:1
263:7 306:13	56:24 57:1,12	353:16	167:10,23
324:9 331:2	57:19 64:20	patterns	175:6,7 176:24
339:2 355:2	131:10,17	111:18	299:5 350:14
parsimonious	134:12 140:17	paucity 202:19	peers 59:7
183:1	147:17 157:21	204:20 205:1,1	344:10
parsimony	234:17 235:6	pause 12:16,17	penalty 360:1,4
182:18,20,21	254:19 273:17	paying 211:1	pending 13:10
182:24 198:11	274:22 299:10	235:7 356:2	people 36:20
part 20:6,12	particularly	pb 306:11	45:8 54:1
34:22 37:4	36:24 42:22	pce 6:21 8:11	57:19 75:4
41:2,3 53:14	47:14 48:9	135:15 136:2	78:10,11 79:2
57:24 112:18	52:14 104:11	140:9 165:14	79:20,22,23
128:8 134:16	184:2 209:9	165:23 168:14	86:11,15,20
135:10 139:9	241:8 281:11	169:13 171:7	104:6 124:16
147:18 148:14	parties 76:23	172:20 174:1	124:20 171:7
148:14 151:6	361:14	174:12,21	190:4,5 208:22
159:18 193:17	partly 289:13	175:8 287:9,9	210:2,14,24
203:2 255:21	pass 271:19	287:14 290:15	235:7 241:24
257:14 274:17	353:17	290:21 298:2	246:2 248:21

256:3,4 344:4 344:13,18 346:13 354:18 perceive 210:9 250:18 percent 236:10 291:10,14 300:11,14 333:10 345:1 perception 190:15 232:18 256:3 perfect 245:6 254:21 281:3 290:11 291:6 perfectly 58:3 112:15 183:21 280:4 perform 99:22 121:10 172:2 192:9 performed 62:22 66:23 117:8,11 135:2 139:19 177:4 252:21 262:17 311:4 performing 95:20 133:9 137:14 141:10 191:16 210:20 268:14 270:6 period 96:19 97:18 99:2	124:7,10,13 132:24 135:2 151:18,21 152:7 159:16 168:8 170:19 195:11 197:1 202:20 204:21 205:7 215:14 215:16 263:4 266:24 274:8 275:3,10,14 276:10 283:22 284:2 293:4 317:4 periods 151:22 274:2 282:24 347:8 perjury 360:1,5 permeability 111:12 313:1 permeable 48:13 person 55:7 89:9 108:8,9 348:10 personal 44:22 personally 29:21 51:5,16 60:1 persons 349:8 perspective 15:21 57:21 190:10 233:16 233:18 327:6	338:21 348:22 349:7 356:22 perspectives 70:6 pertaining 19:6 pervasive 73:20 347:13 pest 80:14,16 81:1 261:4,5 pesticides 74:21 phase 176:5 phd 1:13 2:12 5:2,15,19 10:14 26:7 61:14 162:3 360:19 philosophical 243:17 254:4 philosophy 43:18 254:3 phone 73:4 144:14 355:7 phrase 224:23 226:7,8,12 357:16 physical 149:12 152:22 154:6 154:12 240:13 314:10 316:16 355:2 physics 55:4 197:13	picking 149:15 279:6 picture 288:2 291:6,6,7 pilot 47:8 49:1 49:2 50:9 53:5 54:8,11 237:17 pinnacle 248:9 place 16:23 75:19 83:8 88:12,18,20 93:20 110:4 163:7,14 167:17 175:5 204:10 244:1 262:18 307:20 361:10 placed 262:23 places 63:10 222:21 238:11 238:20 281:19 281:20,21 334:5 336:18 plaintiffs 3:3 3:13 9:20,23 69:20 139:10 147:19 plan 54:6 153:4 planned 49:9 planning 49:16 105:8,9 113:24 114:7 122:11 plans 154:8,13
--	--	---	---

plant	47:8 49:1 49:2 50:9 53:5 54:8,11 87:23 237:17 272:10 272:13 280:14 298:3 300:18 300:23 301:6 332:21 339:4 339:14	49:5 60:16 72:1 90:22 91:1 93:9,12 94:17 95:21 96:8 97:7,15 99:12 111:24 112:1 116:11 120:11,18 121:6 138:18	320:22 323:14 324:15,22 325:1,5,12,14 325:16,21 350:2,4,12,13 354:16 356:4,5 pointed 14:6 216:19 291:10 291:13 305:9	porosity 111:12 113:6 181:1 197:21
plants	47:17 122:4 231:1 275:21 299:11	139:6 141:13 143:6 145:7 146:2,18,18	305:12 313:12 314:21	pose 48:17 poses 64:14
played	78:4,8	147:15,16	pointing 313:6	position 37:23 89:11,18
pleasant	3:7	152:4 153:22	points 15:16 16:1 36:19	positive 46:6 91:16 270:16 286:11 317:9
please	9:17 12:24 35:7 85:24 149:14 155:8 193:24 322:12 358:9	159:5 160:8 180:11 200:22 205:11,19 209:10 215:23 219:13,18,21	60:16 112:12 154:23,23 265:20 281:16 287:18 288:18 288:18,21,24	possession 21:14 310:14
plot	295:16	221:19 224:7	289:2 290:1,2	possibilities 245:7 259:11
plots	248:14	244:7 250:5	291:2 292:12	possibility 174:1 217:17 250:20
plotted	288:6	254:19 260:23	292:13 296:20	
plus	70:13 259:5,6	265:20 268:13 276:22 277:3,8	politicians 42:24	possible 11:13 12:23 172:8
plutonium	47:14,22	279:22 280:17 281:2,4,5,15	poor 277:15 295:20 296:1	173:22 175:19
pm	161:6 162:9 199:12 261:15 261:18 297:15 330:14,17 358:12	283:20 285:8 285:12 286:4 291:3 298:11 298:17 299:2 305:16 307:9	296:10	182:1 183:1,17
point	7:8,21 8:5 13:7,23 16:16 34:6,15,20	308:1,7,17,19 308:20 309:14 310:3 320:9,15	pop 20:10 popped 46:7 popper 243:18 population 88:2 125:11,17 126:4 179:12	192:16 198:10 207:10 210:5 211:9 216:7 220:2 226:14 245:20 255:18 258:12 259:15

possibly 181:3	precise 196:5	254:18,23	112:8,8 121:24
postaudit 8:14	198:3 225:15	264:9,14,16,22	123:7 180:14
252:7,19 262:5	275:16 276:10	295:11	195:22 288:1
263:16 264:1	307:20 310:4	predictions	342:3
264:13 294:1	precisely	157:11 262:17	presentation
postaudits	251:11 252:1,2	262:22 263:17	204:4 208:22
262:15,16,21	327:15,23	264:2 295:15	294:22
263:2	338:10	295:21 296:11	presentations
potential 51:7	precision 96:11	323:22 338:17	32:18 40:11
140:7 147:11	202:9,18 203:9	346:11 347:5	52:5 86:17,20
153:10 205:12	204:19,24	347:12	87:2 216:5
205:21 206:1	206:6	predictive 8:12	presented
237:20 277:17	preclude	155:21 293:23	54:19,23
potentially	231:20 232:23	pregnancy	196:11 347:12
250:14	233:13	136:10	348:3
power 47:17	predetermined	pregnant 133:1	presenting
prabhakar	107:22 108:5	preliminary	347:18
343:14	predict 103:13	86:6 87:13	presents 64:11
practical 353:6	115:1,13,14	173:9 208:24	preserved
practically	121:19,20	preparation	334:14
271:17	123:3,5,10	147:4	press 40:22
practice 110:16	127:10 153:2	prepare 13:19	pressure
211:12 229:4	211:4 263:12	17:19,20 18:6	113:21
241:6,7	264:8 346:5	67:9 86:8	prestigious
practices	predicted	102:20	57:8
196:11 224:21	294:13,17	prepared 116:7	presume 41:23
225:13 235:1	295:6,14,18	201:23 209:2	69:5 88:4,13
277:15 346:4	296:7	222:11	172:3 342:13
357:21,21	predicting	preparing	pretty 36:4
preceding	240:15	250:5	49:7 54:17
270:12	prediction	presence	55:7 96:5,6,7
precipitation	195:13,19	295:21 296:11	98:6 113:5
170:24 256:24	253:16,17,21	present 4:16,18	118:6 173:11
	253:22 254:2	14:11 17:3	176:1,2 254:15

300:12 301:4	196:16 209:2	problem 6:1,6 40:3,6 46:15 70:1,2,6 74:3 81:10 96:20	111:14 117:16 181:6,10,14 182:3,6 184:14 184:19 193:18
319:12 342:5	219:22 221:21		
343:8	226:12 229:20		
preventing	246:20 333:17		
154:15	probabilistic	118:15 124:17	197:7 198:2,4
prevention	55:5	124:21,24	198:13 241:1
152:24	probably 16:10	129:5,16 151:7	251:23 257:23
previous	17:15 22:14	151:11 152:21	299:7 316:17
149:20 205:14	24:13 30:7	159:4,8 212:11	proclaiming
286:2	31:15,17,19	218:15 220:6	243:21 247:11
previously	33:8,9,23 38:1	290:7 315:8	produce 57:15
162:5 326:16	38:13 42:6,24	354:18	187:23
328:12	56:22,23 61:11	problematic	produced
primarily	71:15,24 73:4	350:3	20:20 43:8
353:5	74:3 76:16,22	problems 46:1	66:2 67:8,13
primary 52:15	81:10 85:5,19	81:9 90:1	68:8,15 69:8
74:20 118:16	85:22 86:14	104:12 124:16	69:14 84:10
123:15 270:20	90:8 93:10,17	129:19 208:15	119:15 137:12
principal 77:11	131:8 163:10	208:16 209:12	159:24 224:6
77:22 80:20	167:12 172:13	262:22 263:4	234:1,10 251:6
principle	174:8 185:7	process 106:15	310:13 337:4
159:21	189:11 198:14	106:16,21,24	338:18
principles	205:10 209:10	134:3 140:15	producing
108:23 212:2	232:10,14	198:6 258:5,6	353:7
240:13 241:20	237:1,4,6	258:9 259:16	product 218:18
260:16	252:8 254:15	299:4 300:8	production
printed 109:17	268:4 288:19	306:10 308:23	19:11,13 47:15
prior 19:6	290:1 315:16	309:8,9 314:11	products 47:22
21:11 72:20,21	320:13 321:15	318:12 327:2	219:1 346:19
99:2 122:19	322:3 324:2	328:15,22	professional
124:8 126:12	325:2 342:5	339:13	29:22 30:1,13
130:7 141:15	350:24 354:19	processes 38:8	33:12 36:22
162:21 165:9	probing 173:16	38:13 108:1	39:12 72:9,14
165:11,15,21		109:19 111:11	80:8 155:9

233:8 235:10 235:24 236:2,5 236:7 professionally 36:11,18 professionals 231:24 233:5 233:14 234:3 234:11 235:14 235:19 professor 44:18 53:8 341:11 343:13,24 program 71:9 102:13,14,17 progresses 214:20 project 74:1,4 78:13 115:8,10 115:11 207:9 216:12 projects 32:7 72:5 153:4 pronounced 242:10 proper 131:9 131:20 properties 111:5,11 112:2 112:6 113:18 118:11 171:1 180:19,20 190:13	property 118:22 proposed 47:12 49:2 55:13 115:20 128:9 214:14 215:4,5 protect 190:5 191:12 192:11 protecting 191:18 protection 63:15 191:13 protective 187:12 190:3 190:11 192:23 prove 245:21 253:14,24 264:4,6,10 281:3 357:12 proved 264:20 provide 91:3 94:16 179:5 202:8 229:23 230:19 330:1 332:16 provided 87:11 94:22 231:3,7 352:4 354:11 provides 152:24 providing 169:2,3 203:8 206:5 231:5,22 233:4 310:19	337:1 351:14 354:12 public 2:22 42:23,24 63:20 186:14,21 187:1,4,11 188:5,9 190:2 190:11 191:16 192:8,11 243:15,21 244:1,4,5 247:11,16 250:18 348:15 361:4,21 publication 37:2 243:4 publications 5:20 36:22 37:7,11 published 16:5 37:2 40:21 87:15 101:12 204:9 218:23 242:21 243:1 250:10 293:21 342:15,16,17 344:3 357:15 publishing 342:11 pull 265:2 308:15 pump 31:10 104:7	pumpage 32:4 276:4,11 pumped 275:2 pumping 115:2 174:12 180:23 272:11,17,21 272:24 273:5,6 273:10,12,16 273:21 274:15 274:21 275:3 275:12,13 276:6 320:15 354:23,23 punishment 13:9 purpose 46:19 49:19 87:17,21 109:24 114:15 122:14 123:21 124:1 126:18 127:5,8,19 129:6,16,21 134:6,18 136:19 137:10 141:12,18 142:7 145:21 146:1,3 147:10 148:15 158:13 158:18,22 160:10 212:12 213:8 230:4,5 234:17 236:20 237:19 238:9 336:15,24
--	---	---	--

343:1 352:10 356:16 purposes 31:24 49:17,17 50:18 114:1,8,13,14 114:18 115:7 122:12 154:18 154:21 233:22 234:20 237:24 255:6 265:14 275:10,13 355:10 pursuant 2:20 pushed 78:12 put 13:10 69:15 85:24 105:17 108:6 142:16 191:6 239:9 putting 25:9 351:2,12,13	207:9 quantitative 107:10 115:5 346:17 quantitatively 107:24 question 12:17 12:21,22 13:3 13:11,11 24:16 25:3 29:16 35:10 52:7 56:12 57:10 59:9,18 60:6 74:5 79:18 80:18 81:17 84:7 92:5 119:16 122:7,8 122:19 125:15 126:6 133:14 134:23 135:12 135:12 136:22 136:24 137:6 137:16,18,24 138:7,12,23 139:12 141:4,6 141:15 142:2 143:9,12 144:2 144:13,16,20 145:2,10 146:7 146:9 147:23 149:20 160:4 166:2 168:11 169:1 172:19 173:11,17	179:15 186:6 188:1,11,17 189:22 191:20 192:13 196:20 196:21 202:7 206:14,24 221:6,9 223:8 228:20 234:22 236:9 244:24 246:17,21 249:3,23 250:1 257:15 276:17 277:18 292:4 292:10 303:15 333:8 335:14 352:23 questionable 328:16,23 questioned 216:20 questioning 54:19 144:24 149:15 questions 14:5 15:12 24:24 37:13 52:8 55:8 86:5,6 87:3 91:11,13 92:8 103:8 128:19 143:21 156:9 162:22 201:20 203:20 203:24 208:21 209:4,5 216:20	227:19 230:5 230:15 294:3 297:7,23 330:19 340:1 345:20 353:16 353:22 354:1 358:1 quick 261:10 297:8 quickly 113:22 176:2 278:8 292:10 342:5 quite 49:4 73:5 79:7 202:15 214:15 215:6 262:23 282:23 297:2 323:21 350:15 quote 239:16 239:20 285:2 quoting 247:1 336:17
q q&a 135:10 qualified 138:24 190:8 qualitative 107:9 qualitatively 327:21 348:23 348:24 349:6 quality 102:8 259:18 348:21 quantify 134:11 140:16			r r 3:5 9:1 radioactive 47:14 49:10 55:13 109:3 128:9 rail 55:14,19 railroad 55:16 railroads 55:12 raised 216:18 216:20 219:19

221:6,9 247:2	327:10,19	133:3 134:4,9	349:3 360:5,7
311:3,5 312:6	330:2	134:20 135:20	reading 225:4
312:9,17	rates 171:10,14	136:4,14,23	248:7 266:13
raising 270:3	203:7 206:4,10	140:5,21	266:18 278:16
317:14	272:21 317:9	144:12 145:5	286:9 330:6
random 108:5	319:6,10	147:3 151:13	reads 103:11
range 169:23	354:23	153:6 155:24	119:13
248:17 260:13	rather 263:10	157:15 164:5	real 45:24
266:21 279:14	316:16 320:15	168:15,16	106:14,20
279:17 284:1	334:7 336:7	170:4,5 172:15	123:11 127:6,8
293:1 318:21	351:23	172:16,17	138:21 146:21
319:9,18,21	ratio 302:23	173:9 176:21	165:16 198:13
332:20 347:16	reach 266:8	176:22 177:15	208:17 217:13
ranges 332:2	267:17,20,22	178:12 185:21	240:1,3 287:20
ranging 55:3	268:2	194:24 201:1	331:4
rank 334:10,13	reached 135:17	202:22 203:10	reality 110:14
338:10	reaches 175:21	203:11 208:1	112:15 198:2
ranked 334:9	189:15	215:1 219:13	228:22 229:11
351:23	reaching	223:14 230:1	353:10
ranking 336:2	266:23	232:3 240:17	realization
rare 276:9	reaction 181:17	242:16 244:11	266:22
rarely 113:18	183:10 203:7	245:5 249:9	realized 20:1
263:3	206:4,10 302:8	252:8 263:14	really 25:2
rate 65:11	322:20,23	267:1,10 270:1	27:22 30:2
66:10,19 67:18	reactions	270:2,12 271:2	50:4 61:1
70:15 115:2	157:22,22	271:22 275:18	104:21 115:21
171:9,10	206:11 302:20	283:7 284:18	116:19 173:14
273:16,22	302:21	284:21 286:15	184:21 190:11
276:20,24	reactive 302:3	290:24 294:18	196:1,13
317:2,13,23	read 28:10 29:3	295:22 300:2,4	209:24 210:16
318:5 319:16	34:12 103:17	306:15 318:2	210:20 228:13
321:21 322:4,7	106:17 110:17	328:17,18	234:19 236:1,1
322:13 323:7	110:21 122:5	333:2,3 335:9	242:23 253:23
326:14,19	130:9 131:12	335:10 340:18	265:21 268:7

279:10,19	323:19,22	recall	11:10	300:12 305:18
283:5 288:1	327:5 331:6		14:15 16:6,19	306:13 319:15
289:23 291:3	350:21 351:3		17:9 26:22	319:20 322:9
297:2,3 301:1	354:9		31:14 32:20	325:3 327:23
302:23 304:2	reasonableness		33:4,17,24	329:3,11
304:18 313:9	289:4		40:24 44:12	331:19 341:17
339:10 340:19	reasonably		45:9,14,21	342:10 343:22
342:8 344:2	64:14 213:6		46:2,9,12,18,22	345:17
352:18 353:15	234:6,6 235:23		47:1,2,4 53:3	receive 60:10
355:24	236:17 339:20		54:2 70:23	68:20
realm 56:16	350:22 354:8		71:21 72:7	received 19:10
245:7	reasoning		73:3 74:21	36:23 37:1
realtime 2:21	253:10		84:5,14 85:20	61:19 67:22
reason 11:21	reasons 197:18		86:16 87:6,10	69:8
167:5,22	247:6 284:9		87:12,15 88:24	receiving 209:3
168:22 169:7	357:14		90:21 91:7,10	recent 38:19
212:4 217:11	rebuttal 5:10		91:10 92:7,16	311:17
222:6 226:5	5:14 22:3,7,9		92:19 93:5	recently 218:6
236:18 257:14	22:21 23:16,21		94:15,21 95:3	219:8 311:6
257:15 317:24	23:23 25:23		95:4,6,15,19	recess 83:14
320:24 321:2	26:7,17,18		97:4 105:14	161:8 199:10
reasonable	27:2,6,9,20,24		139:13 143:2	261:16 297:13
35:2 57:4	28:4,19 29:5		147:24 163:1,6	330:15
70:15 98:21	37:6 65:6		175:12 180:4	recharge
171:2 182:9	75:23 116:3		180:10 185:23	170:23 171:2
202:15 212:15	148:5 150:23		186:24 203:22	recite 272:18
214:15 215:6	151:1 156:17		204:6 205:18	reclamation
223:3,9 224:8	163:24 164:1		206:9,12 209:1	154:8,13
224:11 233:20	185:1,7 222:15		216:2 220:5	recognition
251:13,19	222:17,23		226:15 230:8	36:24 225:10
255:3,6 260:10	246:5 252:14		237:21 239:1,2	320:14 323:23
289:15 299:12	300:1 331:22		252:12 272:16	351:19
313:17 314:16	341:23		272:18 274:1	recognize
318:21 323:12			275:18 300:10	124:21 195:15

196:6 201:18 229:10 recognized 40:5 96:20 124:24 151:11 159:8 231:19 314:12 316:17 346:14 recognizes 196:2 319:1 recognizing 248:3 recollect 175:10 299:8 recollection 16:1 31:1,15 31:16 32:16 33:1,10 40:1 40:18 49:1 82:21 88:22 89:16 94:1,8 180:6 191:22 201:19 274:13 275:16,19 299:5 339:17 recommended 214:10 reconstruct 34:14 97:9 125:11 126:2 126:10,17 127:4 141:19 152:6 197:5 229:19 276:6	277:1,7,19 reconstructed 170:21 202:21 204:22 273:7 277:21 reconstructing 124:6 149:6 159:19 206:15 reconstruction 7:1,6,19 8:3 50:12 123:16 125:7 127:18 134:3 135:13 140:16 149:5 200:20 274:18 275:10,14 276:1 350:2 record 9:4,18 10:10 12:3,9 67:6 83:13,16 83:18 124:13 137:1 155:10 161:5 162:9,14 170:20 199:6,9 199:12,14 218:10 261:15 261:18,20 263:12 273:5 273:11 277:11 280:11 286:15 286:17 297:12 297:15,17 330:14,17 358:11	recorded 1:12 2:11 recording 171:7 records 66:2 163:9 170:24 276:10 recreates 112:15 reduce 182:16 reduction 317:16 reevaluate 34:18 refer 26:4 118:18 217:21 238:21 250:12 285:13 reference 156:17 166:6 185:11 243:18 265:14 284:6 292:8 293:9 referenced 25:7 references 63:9 referencing 268:12 referred 250:12 referring 53:5 97:19 98:8 157:4 171:24 180:1 205:4 206:10 246:4 277:3	refers 285:23 refine 182:2 186:15 235:5 refined 176:19 177:21 178:5,9 180:1,9,14,15 180:16 181:2,5 181:13,20,22 reflect 191:8 193:15 195:24 248:17 286:18 288:3 297:5 313:3 reflected 25:12 27:21 28:18 186:18 217:2 219:20 222:14 241:20 reflecting 21:3 61:17 219:18 219:22 244:21 reflection 289:3 reflects 63:16 64:15 302:2 331:4 refresh 16:1 42:10 regardless 111:3 235:2 330:1 334:11 334:14 336:20 region 89:15,22
---	---	--	--

regional	89:11 89:14,17,19,24 213:9	338:12 339:2	relied	233:21	remote	10:8	
registered	2:22 361:4	relates	1:9 146:17	rely	212:24 234:3 318:15	removes	351:24
registration	361:24	relating	306:1 349:17	remain	109:8 111:8 180:22	removing	154:8,14
regression	276:1	relation	58:4 142:24 294:13	remains	111:4	remy	5:11 76:6 76:19,21
regulatory	43:9 56:4	relationship	295:13 303:12	remediation	115:24 157:14	remy's	27:23
reich	4:19	relationships	108:17 335:4	remedied	152:23	repeat	35:7 81:17 114:3
reilly	101:23 102:1	relative	289:19 290:4 334:7 361:13,15	remember	16:14 17:10,11 30:3 32:17,19	repeatedly	137:6 141:5 144:1 188:11
reilly's	129:11	relatively	295:16			reply	194:5 249:24
reiterate	194:17	relevant	145:19			report	22:3,4,7,9,12
related	21:11 27:13 29:8 30:19,22,23 32:2 34:6 46:16 47:15 52:6,13 62:23 64:6 67:23 72:6 75:6 86:24 90:19 91:5 97:7 99:13 116:23 127:14 149:18 163:4 164:15 164:19 165:1 190:14 191:17 211:7 261:8 314:10 316:9	reliability	210:20,22,24 203:2 210:12 214:18 215:9 317:1	remember	16:14 17:10,11 30:3 32:17,19	repeatedly	22:19,21 23:14
		reliable	43:2,21 57:5 91:21 98:6 191:6 214:10,24	reliability	42:3,6,8 44:9 55:11 58:14	reply	23:17,21,23
			234:7 236:17 240:14 264:16 317:24 318:6 350:22 354:8	relevant	73:1 75:15 80:8 86:2,4,9	report	24:5,20 25:6,7
				reliably	89:1,4 90:4,9 92:12 93:6,13 93:16 94:2 117:5 159:11		25:12,23 26:7
					167:2 169:18 172:4 178:10 203:23 218:24 220:4,22		26:18 27:2,7
					221:11 226:14 292:16 317:7		27:10,12,17,21
					317:18,19		27:22,23 28:19
					321:24 322:1		28:19 29:2,5
					322:22 327:14		35:4,21 37:6
					331:23 342:1		40:17,21 41:1
					remind		41:11 42:6,9
					74:5		45:20 56:23,23
							57:2 63:8 65:7
							75:23 116:3
							117:2 121:14
							121:15 123:9
							138:18 140:5

146:14,24	reporter	2:21	represent	67:13
148:5 150:22		2:22 10:11	18:18 65:23	requested
150:23 151:2		12:1,9 35:11	158:4 181:9	203:24
156:17 157:6		65:17 100:17	201:14 224:13	requests 19:1
163:21,24		144:12 161:4	251:13,23	21:5
164:1 185:1,7		361:1,4	302:22 331:14	require 184:14
185:11 186:7	reporting		345:8	276:3
204:9 219:21		347:5	representation	required 130:7
220:4 222:15	reports	5:10	92:11 106:14	131:3 157:13
222:17,18,23		13:21 16:5	106:20 198:4	230:22
224:3 227:6,13		18:2 24:9	241:1	requirements
238:12,15,21		26:18 27:20	representing	131:6
239:5 246:1,4		28:1,4 34:3,4,6	3:3,13 4:3	requires
246:6 252:7,15		34:10,12 56:22	184:18 208:11	103:13 114:21
252:17 275:18		57:3,14 75:24	represents	reread 146:24
278:8,17,20		86:8 87:14	225:15 302:23	219:13
279:10 283:16		89:20 99:17,20	reprinted 7:16	rerun 327:19
283:18 285:22		116:7 117:6	242:22	research 38:2
288:11 290:20		138:16 139:7	reproduce	39:15 40:7,21
291:3,9,12,17		145:5 146:19	54:22 158:23	56:2,9,14,19
300:1,5 305:20		147:3,6,17	reproduced	57:24 102:13
307:20 308:15		148:1,24	57:16	102:14,17
308:17,19,19		217:18 218:20	reproduces	340:4,5 341:19
312:8 322:15		218:21 219:3	150:6	344:8 353:8
323:1 326:10		219:12 220:1	republished	research's
331:22 333:12		221:11 223:22	243:8	56:19
340:6,11		250:3,4,5	reputable 57:7	resided 133:1
341:16,23		278:11 311:6	reputation	resident 347:22
342:4 345:11		311:17 347:14	56:20 59:23	residents
345:11,14,16		347:24,24	60:1 79:23	176:17 177:19
348:4		350:20	reputations	232:1 233:6,15
reported 1:23	repository		79:21	347:7
288:22		48:12 128:5,9	request 19:15	residing 349:9
			20:22 21:2	

resigned 72:2	256:24 263:12	207:8 209:24	retarded
resource	311:10,11,16	210:14,16,19	157:21
103:22 104:3,4	311:16 313:19	210:24 212:18	retention 19:7
104:9,16,17,17	314:19,20	212:24 214:11	21:12 72:21
105:3,5 115:4	315:13 317:20	214:19,24	219:22 221:21
152:21	322:10,21	215:10 216:14	retired 39:4
resources 7:7	331:15 333:17	218:5 224:15	53:14 69:24
7:20 8:4 89:13	333:21 335:4	224:18 228:1	70:9 77:15
184:3 200:21	335:12 338:15	229:6 231:18	retiring 77:21
243:6	342:17 343:8	231:21 232:24	return 176:6
respect 131:5	responses 8:18	236:4,6,16	189:19
193:7 244:3	169:24 256:22	239:18,23	reveal 14:24
247:15,24	257:3 310:20	248:1,4,14,23	revealed
274:15 280:23	310:22,23	255:17 258:1	257:12
311:3	313:5 342:21	263:1 273:24	review 5:23 6:4
respected	responsive	279:6,7,11,12	6:23 14:22
56:22 57:21	19:14	280:16 290:14	15:1,2,10,13,20
respond 12:18	rest 104:5	324:4 334:2	17:7 24:8
14:6 283:14	329:20 341:6	339:15 347:15	26:17 27:2,6,9
responded	reston 102:11	350:21 356:11	27:17 28:7,13
19:22 217:7	163:16,17	retained 69:9	32:13 34:10,22
responding	restoration	219:3	43:4 54:5,14
83:3 332:17	258:7	retardation	54:18 69:23
333:16	restricts 257:8	6:21 157:10,19	75:4 76:15
responds	result 107:21	181:9,12,16	86:8 87:11
186:12 283:12	136:1 153:1	197:24 198:14	91:16,18 92:4
285:20 333:16	213:6 259:5	198:16 301:11	95:1 166:19,19
response 19:15	322:16 356:9	301:19,20,24	167:10,23
20:21 21:5	results 43:22	302:1,22 303:1	175:7 176:24
75:24 84:10	88:8 108:4,11	303:7,13,20,24	204:3,7 252:9
92:13 103:14	177:13 185:14	304:3,12,14,18	300:4 310:21
138:1 164:6	185:16,19	304:24 305:11	311:17 312:7
203:20 207:2	188:8 196:4,11	307:18,23	313:24 319:14
230:14 245:1	196:16 205:17	318:13,19	331:20 342:23

343:6 350:14	69:11,16,17	187:23 188:15	risks 64:6
reviewed 13:21	74:11 75:12	195:2 196:18	river 213:9
15:23 16:7	77:8 78:1 82:3	204:11 206:24	256:23 294:15
18:2 138:16	88:2,12,14	210:21 212:13	rnr 1:23
203:5 238:2	92:22 93:16	222:16 225:8	361:21
250:3 252:6	97:1,5 99:17	225:19 226:24	roads 170:1
300:17 311:6	99:23 101:9,13	228:18 230:16	171:19
reviewer	101:20 103:5	234:20 248:7	robert 89:7
173:10 299:11	106:1 107:1,16	249:1 250:19	313:18 318:4
315:16 316:19	108:18 110:5	251:7 256:1,2	322:10 326:8
328:9	110:23 112:15	260:24 268:3	328:6 353:1,2
reviewer's	114:1,8 115:9	268:10,14,23	rocky 6:17
326:17	115:24 116:23	269:6 270:12	73:19 74:12,18
reviewing	117:6,9,12	277:4,24	75:6 148:18,22
15:13 16:20	120:12,15	279:13,16	149:4,18
17:11 34:2	121:2,7 123:5	280:18 284:15	150:17,20
218:6 237:4	125:13 126:4	285:3 290:12	151:6,9 152:15
300:1,3 321:13	128:23 129:7	290:22 293:21	154:24 155:2
reviews 18:16	129:10,13	296:3 298:3,8	162:23
25:20 35:16	130:12,15,15	298:9,20 300:8	rod 53:19
101:14 169:9	131:21 137:14	309:4 310:16	rods 47:17
223:18,21	138:5,10	324:17 325:17	rogers 6:22
278:15 313:21	141:24 143:23	329:2,18 330:4	156:18,19
rf 198:21 305:5	145:8 149:7	335:16 344:10	157:3
306:9 307:5	151:19 152:7	355:6 357:12	role 38:19
rfs 197:24	152:17 154:16	357:12	39:23 40:12
rice 3:4	154:17 156:14	rigorous	43:16 51:24
right 12:2	156:18 158:12	238:16	52:3 78:5,8,9
17:17 26:10	158:21 167:6	risk 48:11,17	93:4 335:21
32:1 33:13	167:24 169:16	52:12 53:24	344:8
34:7 37:8,17	170:8 171:21	55:4 63:18	roman 132:10
38:16,21 39:15	172:2 174:3	64:11,14,16	140:2
39:21 42:15	175:15 177:4	188:9 334:20	room 2:12 17:1
54:7 68:18	186:10,21	335:5	

rounded	sample	290:6	210:15 225:18	336:17 349:24
102:23		320:14	225:20 233:17	356:3
routine	sampled		239:2 250:24	sc 3:7
274:7		283:21	268:1 272:2	scale 228:16
row	samples	96:24	274:24 275:2	292:23 336:3,7
307:5		98:4 122:3	306:20 309:7,8	349:18
rule		229:21 283:22	318:4,10,24	scarcity 105:14
182:4		288:1,3 290:3	322:11 323:2	scatter 296:15
rules		293:10	327:3 329:7,9	scenario 346:6
11:12	sampling	97:21	335:12,16,24	350:4
144:6		320:18	336:14,24	scenarios 52:11
run	sandy	313:13	352:9 357:8,18	271:6
119:9,12		sat 11:7 163:4	says 23:2 26:9	schedule
119:12 159:13		216:23	66:8 101:15,15	275:13
168:10 170:15	satisfactory	153:1	107:13,17	schedules
running		108:14 109:22	108:14 109:22	354:24
169:22	satisfies	110:9 116:5	scheduling	18:20 271:5
255:18		130:1,22	scheme 217:9	scholars 59:6
s	satisfy	131:18 132:15	schwartz 44:17	science 45:18
s 9:1	saturated	133:22 135:12	55:4 58:8,19	55:4 58:8,19
s.s. 78:22,22		140:5 147:1	59:5,15 60:9	59:5,15 60:9
79:14 81:13,15	save	152:19 157:24	240:1 241:22	240:1 241:22
81:18 82:4		164:18 169:12	357:14	357:14
sabatini 27:3,5	saw	170:9 171:22	science's 59:23	science's 59:23
33:19 300:6		185:13,15,19	sciences 56:10	56:17 58:2,6
sabatini's		216:13 217:18		58:11,19
300:1,5		218:9,12 219:1		scientific 15:21
safe 64:14		320:24 350:19		136:12 191:5
187:6	saying	228:10 231:15		191:24 192:16
safely 129:23		239:22 242:22		196:1 223:3,10
safety 48:5,21		263:11 265:23		
48:23 49:18		269:18 276:16		
50:5,6 55:16		290:13,19		
128:8,10 188:6		306:7 326:9,14		
salary 68:24		327:17 328:6,7		
100:10		328:20 332:5,8		
salt 47:13				
294:15				

223:23 224:8 239:15 241:4,8 243:14,15,16 244:20 scientifically 224:19 226:3 238:17,22,23 239:3,19,24 240:4,11,21 241:13 242:2 244:14 245:1 245:13 246:13 247:18,19 251:3,4 357:17 scientist 15:22 60:10,11 102:2 scientists 118:5 scope 61:22 scratch 178:15 292:6 se 323:8 sealed 48:10 second 12:17 22:8 40:16 87:7 108:13 109:23 146:16 151:3 171:16 194:15 199:4,7 206:14 227:16 239:10 240:7 243:19 247:10 285:17 295:12 330:7 345:24 346:3	section 61:4 103:8 110:9 128:20 172:18 212:5,7,8 222:24 227:13 239:14,14 242:17 262:15 284:20 sediments 111:16 see 19:8 36:20 46:10 67:5 112:5 130:24 131:1 132:13 146:24 161:2 163:8 166:22 182:2 191:3 192:2 194:12 201:12 202:5 206:17,20 221:16 223:6 227:14,20 269:12,16 270:11 278:12 279:11 282:7 291:18 296:20 308:11 310:2 322:18 326:11 327:20 328:8 332:13 342:4 seeing 139:14 148:1 220:5 272:18 280:16 331:23 345:18	seeking 69:22 seem 130:2 270:8 349:16 seemed 96:8 98:5 123:15 124:4 299:11 299:12 323:12 352:3 seems 75:16 158:17 167:3 182:9 280:7 288:6 328:9 329:8,13 331:6 353:4 seen 18:15 76:16 166:5 225:3 258:2 331:18 333:10 345:13 select 100:22 137:1 selected 39:11 41:13,21 42:1 43:24 44:7 52:18 selecting 40:12 selection 192:3 213:20,21 sending 20:3 senior 43:1 sense 47:17,19 52:3 91:17 121:18 123:1,9 149:9 177:12	208:15 211:10 212:21 213:14 214:3 215:24 245:11,13 248:8,21 250:17 254:6 257:20 259:12 289:14 295:3 300:3,3 307:4 312:21 324:11 324:18 337:11 344:22 350:16 353:7 sensitivity 210:12 229:7 245:24 sent 22:14 27:15 75:4 84:23 86:7 203:23 204:2,7 sentence 23:6 111:2 121:16 129:1 130:22 134:9 142:22 204:17 206:2 212:8 215:4 232:6 247:9 315:13 326:10 sentences 106:3 137:2 separate 17:18 58:17 116:20 120:12 176:5 255:23 290:2
---	--	--	---

325:9	sessions 30:7	shook 30:9	side 31:10,11
septic 266:5	set 21:20 63:15	short 55:17	36:22 185:9,9
267:14	64:6,13,20	82:21 83:19	188:6
sequences	65:3 160:15	199:15 203:23	sight 112:4
275:6	191:7 209:11	261:13,21	signature 22:17
serious 152:21	255:20,23	263:5 274:8	358:15 361:20
157:12 229:4	256:16,17,22	275:5 279:22	signed 22:12
seriously	257:9,11	282:23 283:22	360:15
311:21 312:1	258:24 263:1	293:4 297:18	significant
serve 40:8	343:9 361:10	330:10	24:10 158:5
41:14,21 42:1	sets 191:8	shorter 308:12	252:20 253:8
44:8 52:18	256:7 292:1	shortly 266:6	273:23 299:9
69:19,23 85:16	setting 63:23	267:14	306:9 314:18
92:24 93:2	64:23 110:12	show 248:14,16	315:9
109:1 344:13	settings 30:13	253:7 271:16	significantly
served 19:18	several 13:21	292:24 308:16	271:9,20
39:14,19 41:18	14:14 19:23	309:3,4 332:16	silverstein 4:7
42:4,13 44:13	72:24 74:11,14	showed 98:5	10:6,7 160:24
47:7 50:15	79:1 85:5	196:13 218:12	similar 16:13
68:3 73:8 85:9	102:13 151:21	293:12	87:20 159:21
92:20 100:6	169:4 178:12	showing 183:13	238:2 244:5
339:6,18 340:3	215:14 262:16	196:12 254:7	294:20,22
344:7,17	269:21 270:13	272:12,20,21	308:21 309:17
350:13	287:24 317:4	shown 43:6	309:18
service 20:8	334:21	240:14 288:23	simple 182:1
66:9,16 68:10	severely 250:23	290:2 315:1	183:19 198:10
70:3 222:7,10	sheet 359:1	shows 124:17	198:22 207:17
347:21	360:11	271:12 280:6	298:1,11
servicing 275:4	shell 74:17,24	280:21 287:14	simpler 180:15
275:7	sheraton	290:10 294:16	181:21 183:7
serving 32:13	163:15	shut 271:14,15	simplest 182:24
39:7 99:9	shift 271:8	272:2,6,7	183:17
session 5:4 87:4	shifted 271:13	273:16 274:3,4	simplicity
162:1	271:18	274:8	182:23

simplification	single 96:4 228:22	skepticism	solely 317:5 solid 287:19 294:16 302:3,5
simplified	334:22 349:7 106:20 181:11	skills 62:8,11 skip 142:19 176:1	solute 46:17 49:20 62:2 71:13 74:2
simplifying	181:17 198:22	231:9 328:3 slight 281:22 sit 23:12,17	98:16,17 103:15 110:1
simply	106:13 260:2,3	26:12 28:2 29:11 36:7	120:2 157:11 170:17 217:23
simulate	121:5 127:21 129:20 325:16 326:18 327:9	138:15 147:4 site 45:22 46:5 46:13,20 47:12	241:9,18 267:7 300:16 316:17
simulated	137:11 224:5 233:12 234:1 235:17 251:6 255:17,22 259:13 279:11 279:16 280:16 283:18 287:9 289:21 290:15 296:2,3,7 326:20,21,24 327:11,12 332:21,24 334:15 338:17 347:23	48:6,7,9 49:6 49:10 50:6 51:4,9 52:6,13 52:19 55:14 127:9 128:12 156:14 158:9 158:19 204:5 294:21 312:3 324:16 sites 45:16 46:3 46:3 47:3	small 262:21 290:6 300:9 308:2,4,10 315:6 320:19 smaller 181:3 259:21,21 smooth 283:19 smoothly 11:13 social 76:23 socialized sitting 11:21 12:2 218:16
simulates	110:1 149:11 150:6	situation 31:12 86:21 88:17 276:22 six 17:15 54:1	72:13 socially 80:11 society 30:5 103:23 104:23 software 80:20 81:3 261:4
simulation	8:9 98:1 318:23	86:6 154:23 203:24	soil 171:1 266:5 267:13
simulations	217:13	skeptical 350:15	soils 122:3 sole 317:24
			316:15,18 338:5

somebody	44:9 85:18	sound	190:16 191:6 238:17	south	13:24 14:10 72:16	92:7,12 95:3,7 95:16 118:14
someplace	124:17		240:12 268:1 298:8	southeast	89:15 89:22	119:11 132:22 138:1 170:15
somewhat	49:3 302:3 322:16 325:7 328:13 328:14,21	sounded	225:18 soundness 203:2	southern	1:3 111:13 111:22 133:19 141:21 198:15	171:10 180:9 188:11 209:13 209:16 217:22 334:19 335:5
soon	67:1 113:5	sounds	30:13 31:22 34:4 44:7 49:13 60:12 88:13		213:22 229:20 356:4,5 spaces 182:3,9 220:1	347:8 specifically 26:22 45:15
sorb	302:4,15		97:5 117:6 161:3 187:18	spacing	181:3 221:3 314:23	51:24 71:21 80:23 87:6
sorbed	302:15		226:18 267:3	spatial	153:15 213:2	97:19 153:13 203:19 345:17
sorption	302:7 302:19 308:20 308:21 309:8,9		272:1 298:9 309:7 346:9	spatially	329:23	specified 115:2
sorry	54:10 60:7 120:1 142:15,17 173:3 218:9	source	95:2 96:4,12 153:21 171:6 205:5,8 209:11 215:23	speak	83:24 94:4,7 199:21 235:14 262:1	speculation 169:22 170:7 170:10
sort	12:15 15:20 45:14,17 46:6,22 49:16 60:16 61:22 63:8 72:12 79:13 113:16 115:7 119:21 186:17 188:8 194:11 200:10 209:18 212:5 222:24 227:2 255:23 279:6 303:11 340:11		267:7 270:20 270:22 272:8,9 276:22 324:1 324:18 sources	80:10 80:10 12:10 57:6 73:2 144:8,9 331:3 special	12:6 12:10 57:6 73:2 144:8,9 331:3 211:7 specialist	185:13,15 193:22 222:18 227:18 239:17 247:1 278:17 281:23 291:13 305:9,24 306:8
			86:23 96:9 196:14 202:20 204:21 205:12,13,18 205:21,21 206:1 207:6 215:21 277:10 277:17 323:5 324:21	speaking	89:19,24 344:6 species	spiliotopoulos 4:22 5:11 76:4 76:10 77:2 83:5 164:7,9 164:13 185:13 185:13,15 193:22 222:18 227:18 239:17 247:1 278:17 281:23 291:13 305:9,24 306:8

333:11 341:22	333:1 357:21	231:10 239:12	216:16 240:9
spiliotopoulo...	standpoint	265:17,21	346:21
200:11,12,13	186:13,14,21	268:13 269:11	states 1:1 4:3
301:14,14	187:1,4,11	276:12 282:19	9:13 10:3,5,7
spills 229:14	188:6 190:3	starts 168:4	35:19 129:3
spite 70:8	stands 63:13	176:10 206:14	139:20 147:17
spoke 73:3	stanford 53:8	322:11 333:16	157:8 166:18
353:12	start 13:18	state 43:5	202:13 206:21
spoken 72:22	37:15 98:1	44:18 45:20	227:17 243:12
85:4 343:20	107:12 124:21	81:3 91:20	271:3 282:21
sponsors 238:3	125:3 151:3	104:11,11,15	295:12 308:16
spread 48:16	159:15 163:24	121:22 151:3	308:18 316:24
96:9 128:4	165:7 168:13	169:20 171:17	319:22 329:17
266:9 267:8,17	169:12,21	223:1 224:20	333:24 346:3
267:23 292:21	171:24 172:21	226:4 238:15	stating 138:18
314:10	174:22 176:15	243:20 245:14	139:7 140:24
spreading	177:17 178:4	246:15 252:18	141:8 146:19
154:15 302:13	181:19,20,21	262:15 323:20	164:21
spring 31:4	181:23 190:2	347:4	station 4:9
153:22	193:5 197:1	stated 142:4	statistical
ss 78:18	222:21 229:15	209:17 252:4	259:19 260:19
stage 207:11	257:6 258:15	268:9 295:24	260:23
stamp 332:5	266:3 302:16	299:8 332:18	statistically
stand 223:22	323:9 355:7	338:16	258:11
224:2 358:10	started 40:16	statement	statistics
standalone	53:7 98:10	131:15 146:19	348:11
59:3 339:13	159:7 175:15	147:6 156:3	statute 226:8
standard 118:5	175:20 188:18	186:18 200:13	226:21,23
181:17 207:17	188:19 189:23	274:5 331:7	stavros 79:2,6
211:12,24	266:1,6 267:15	346:8 347:10	stenographic
221:16 224:20	277:13	349:11 350:8	10:10
225:13 226:21	starting 23:6	350:17	stenographic...
229:4 241:6,11	110:9 130:22	statements	361:9
291:15 332:22	194:11 202:4	145:4 189:20	

step 129:4,17 130:3,5 180:3 212:10 213:22 242:19 257:24 315:4,4	student 71:15 studies 45:22 62:22,22 88:4 88:7 125:18,22 127:11,17	177:12,18 178:4 187:23 211:20 265:21 268:14 269:23 269:23 270:5	84:10 subsection 105:24 109:18 128:22
stepped 53:16	136:11,19	271:9 308:17	subsequent 111:15 339:10
stepping 221:4 314:24	140:7,13 141:1 141:10,24	308:21,22 334:3,5,18,23	subsequently 298:6
steps 214:1,3 280:1 314:5	143:7 145:8 177:10 187:8	336:15 342:12 351:15,16,20	subspecialty 58:15
stick 182:14	209:11,12	355:5,11,19	substance 84:1 162:18 176:1 199:22 262:2
stimulate 116:8	211:3 229:24	356:3,17	substantial 253:18 314:4 315:18,19,24
stipulation 13:9	230:7,20,22 231:22 232:24	subject 19:21 24:3 28:21	316:5,12,13
storage 109:5 118:13 205:22 277:11,14 298:19	233:2,23 237:2 237:22 238:8 262:20 334:22 336:11 337:2	38:10 143:18 243:17	substantially 290:16,22
strayed 74:8	338:22 340:20	subjective 260:17 289:7	substantive 220:7
stream 153:22	352:3,17,18	289:12,13,17	103:13 110:9
stress 262:23	353:10	322:17 328:14	110:10 111:9
stresses 103:16 191:9 208:13 324:8	study 88:2 125:13 126:4 127:20 132:17	subjectivity 323:3	112:19 113:14
stressors 210:4	132:23 133:8	submit 67:4	113:16 174:16
strike 29:9 50:19 126:15 178:15 193:8 195:5 258:15 298:15	133:24 135:2 136:7 137:14 138:5,10 139:19 146:5 150:17,21	submitted 22:4 30:21 66:5 75:22 128:11 201:15,20	174:18 175:9 189:8 215:22 303:9
strongly 110:13	151:6 155:7	submitting 343:18	subtitle 43:7,12
structure 104:22 145:20	156:17 162:23 172:1,22 176:16 177:3	22:19	successful 207:6 208:7
		subpoena 18:19 20:21	334:5 336:15 351:2,11,13

352:8,8,9	132:5 155:13	sure 14:7 22:15	305:3 314:16
354:1,4,11,14	155:16 200:15	24:18 25:2,4	316:13 319:11
successfully	201:10 204:9	26:3 27:12	319:13 320:5
258:14	214:7 216:18	30:9 34:11	320:12 329:2,5
sudden 124:20	217:3 219:20	44:11 45:10	333:9 336:11
suffered 136:1	219:20 265:3	47:11 49:24	338:10 345:1
sufficient 249:5	sunday 20:9,10	52:17 56:15	345:21 348:7
249:11	superficial	61:6,8 74:7	356:4
sufficiently	312:12	76:18 77:24	surface 174:10
234:2	superfund	81:16 88:10	174:12 189:15
suggest 309:13	74:15	89:5 91:2,6,11	189:17 256:20
suggested	supplied 274:6	91:13,24 92:1	256:20
327:8,15,18	supplies 8:23	93:19 94:19	surprising
suggesting	31:9 32:4	96:22 105:22	323:5
20:15	345:10	122:12 125:18	surrounding
suggestion	supply 31:24	126:9 134:17	113:17
311:21 326:9	63:20 178:21	137:8 146:8	survey 37:24
326:18 328:1	179:24 211:5	149:19 156:8	38:16 53:15
suggestive	213:1,5,6,11	158:7 166:4	68:11,12,17
144:7	230:23 280:12	178:8,9,10	69:3,6 71:5
suggests 263:2	290:17,23	181:7 183:13	72:2 79:7
263:8	298:5,7 332:23	187:16 193:12	89:11,13 100:7
suing 74:24	346:12 350:6	196:20 201:16	100:11 102:4
suitable 348:20	supplying	209:15 210:23	suspect 16:15
349:5	274:10 275:23	211:7 213:3	suspected
suites 2:15 9:11	support 88:1	221:3 223:16	316:6
sum 259:5	126:3,8 176:18	228:5 232:14	sustainability
273:21	177:20 178:4	253:10 261:1	105:3,18,19
summarize	supporting	261:12 266:13	115:4
223:19 334:21	187:7	276:24 277:6,9	swear 10:12
summarized	suppose 184:13	279:2 285:15	sworn 10:16
247:7	supposedly	286:8 292:3	162:5 361:6
summary 6:10	262:19	296:5 297:10	symposium
6:13 16:9		303:14,18	30:8

system	87:24 106:14,16,20 106:24 109:12 111:6 112:7 114:20,21,22 114:24 115:6 115:18 118:13 121:21 125:3 131:8,19 145:16,16 149:11 154:3 158:5,24 164:11 170:16 170:17,18 191:9 208:13 208:17 257:4 257:10 262:23 263:10 313:4 324:8 systems	70:10 83:7,10 88:20 116:2 130:4 160:18 160:21 163:14 164:19 175:5,8 189:11,18 195:19 217:13 242:18 261:10 267:19 297:8 298:24 299:2 299:14,18,21 300:15 330:10 taken	169:15 170:12 175:20,23 176:4 182:23 186:17,19,20 186:24 188:14 189:5 195:10 220:9 259:8 260:20 267:4,6 268:13 270:9 270:10,17 279:4 283:2 285:7,9 286:10 292:18 300:10 319:18 351:11 tanks	139:8 140:4 143:5 145:6 146:1 152:4,5 159:22 165:4,7 169:15 171:5 174:1 176:16 177:18 179:11 179:12 188:18 189:4,5 205:14 205:14 219:12 224:6 250:4 265:15 267:4 269:19 270:20 271:17 272:10 276:21 278:10 281:8,18 283:17 285:21 285:23 286:2 287:2,10 294:23 296:18 297:24 298:2,6 298:16 299:1 305:10 307:1 307:24 308:6 308:22 309:13 310:3 315:20 316:2,3 319:6 319:16 323:11 323:13,24 324:16 331:16 331:21 333:5 346:7 347:8 349:9 351:1 354:5,7
		t		
table	115:3 175:21 176:2 189:15 266:9 267:8,17,20,23 268:3 284:6 290:10 take	11:1 13:12 13:15 16:23 41:2 53:22	17:16:16 301:10 305:24 talked	16:16 32:17 33:9 142:21 233:1 235:10 talking
				116:18,20 126:21 137:10 153:12,13 165:4 169:10
				116:10 116:23 117:7 118:24 120:12 120:21,22 124:3 132:6 133:6 134:7 135:11,14 137:12 138:17 138:17,19

targets 289:7,8 291:11	tend 302:4 tended 55:7 271:11	209:11 215:23 220:6 223:21 232:9,15 237:3	146:2 152:5 159:22 165:4,8 169:16 171:5
task 207:3 208:4 214:16 215:6 229:17 334:19	tendency 280:3 tens 205:20 237:4	244:7,9,20 245:9 246:12 259:7 273:14	174:2 176:17 177:18 179:11 179:12 188:18
taught 82:21	term 75:15	280:12 288:23	189:4,5 205:14
tce 140:9 165:14,23	96:12 152:22 171:14 180:4,9	291:16 297:3 304:6 308:23	205:14 219:12 224:6 250:4
tech 45:2	182:17,18	310:3 321:5	265:15 267:5
technical 15:13 15:20 86:19 87:1 95:1 208:22 246:11 252:9 300:4 343:6	195:24 196:1 196:12 205:8 206:11 225:1 226:22 244:19 245:11 250:18 252:23 324:1	324:18 331:1 336:1 337:1 338:5,23 339:21 351:12 353:9 354:2 357:4,5	269:19 270:20 271:17 272:10 276:21 278:11 281:8,18 283:18 285:22 285:23 286:2
technically 65:4	348:21 349:6	terra 120:22	287:2,10
technique 102:24	terminology 247:5,24	terrace 13:22	294:24 296:18
techniques 134:2,11 140:15	terms 15:12	16:9,12,13 34:5,15,20	297:24 298:3,6 298:17 299:1
technology 112:9	36:17 41:9 48:23 59:12 78:9 80:13,16	88:16 90:19 91:5 92:18 93:11 96:3,12	305:10 307:1 307:24 308:7 308:22 309:14
tell 11:16 47:10 185:9 225:2 232:12 289:20 321:23 330:5	95:2 98:22 105:17 113:21 117:15 124:4 135:19 165:15 165:18 172:20 180:14 181:14	97:7,14 98:10 99:10 116:10 116:23 117:7 119:1 120:12 120:22 124:4 132:6 133:6	310:3 315:20 316:2,3 319:7 319:16 323:11 323:13,24 324:17 331:16 331:21 333:6
telling 315:7	181:18 183:11	134:7 135:11	346:7 347:8
tells 289:22	183:11 184:5,6	135:14 137:12	349:9 351:1
tempe 294:15	184:9,22	138:17,17,19	354:6,7
temporal 153:16	186:19 193:22 194:19 205:5	139:8 140:5 143:6 145:6	test 54:22 211:23 256:14

319:5	357:24 358:4,7	think 15:9	204:2 205:3,4
tested 220:5	theoretical	17:21 21:11	208:8 209:17
240:14	203:7 206:5	23:22 24:14	212:14 215:13
testified 10:16	theoretically	25:13 27:15,23	219:24 223:19
18:1 162:5	175:18	32:2 36:4,20	223:23 224:10
testify 11:22	theory 243:16	38:12 41:9	224:12,18
testimony 29:2	353:8	45:8,19 46:4	225:3 230:3
84:1 122:19,22	thermodyna...	53:9,13 54:17	234:4,5,6,7,9
141:16 162:18	108:22	55:10 56:21	235:23 236:17
180:5 199:22	thick 47:12	57:2,14 59:1	239:18,19,23
210:18 216:15	265:7,8	59:19 62:2	241:17 242:1
236:10 246:20	thickness	72:8 78:12	243:5 244:23
262:2 311:15	118:12,19	79:20 82:2,3	247:22,23
358:12 361:9	thing 20:23	82:22 83:7	248:10,11,19
testing 99:23	88:15 102:14	86:4,7,14 87:3	250:24 252:4
217:19 314:23	125:6 158:13	88:24 91:18	252:16 255:5
tests 180:23	164:5 179:4	95:23 100:5	256:4 262:11
220:1 229:7	184:20 254:20	102:6 105:13	263:11 265:6
310:1,1	298:10 302:16	105:17 106:9	268:7 272:14
tetra 45:1	342:21 354:21	114:19 116:15	274:3,4,9,11
tetrachloroet...	things 13:20	120:5 122:12	279:6 281:10
8:11	14:5 15:8 25:6	125:9,24 134:8	281:18,22,22
text 19:4	43:22 44:5	134:16 142:3	283:1 286:10
290:12 295:11	50:2 51:6	148:9 149:23	288:10 289:24
thank 21:19	52:16 61:10	154:22 156:5	291:10,18
29:18 55:23	71:22 74:16	156:16 160:13	292:11 299:24
87:9 90:11	183:14 184:22	160:23,24	303:10 305:14
154:11 163:19	187:9 195:21	167:21 172:11	306:4,17
184:24 199:2	205:23 210:12	173:14 174:7	307:15,19
199:16 207:15	213:13,24	175:16 176:7	308:3 309:6
262:13 286:23	228:15 257:24	177:5,7 179:24	311:1,5,9,20,20
297:9 301:9	280:10 302:20	180:11 188:10	311:24 313:5
310:23 326:7	313:22 320:6	188:22 189:16	314:15,20
349:1 353:18	344:20	191:11 196:9	317:8,9 318:8

318:24 319:13	173:10,14	109:8,12 110:3	313:23 314:5
320:17 323:19	175:17,19	113:19,19	314:23 315:3,4
323:21,22	205:15,20	121:4 124:5	317:11 319:13
324:6,19 325:2	277:18 278:18	125:3 133:19	322:23 329:3
325:3,23 327:5	278:20 313:17	141:21 143:10	330:14,17
328:1 329:15	342:18 347:1	143:11,18,19	349:9 350:16
330:8,11	347:13,17	157:13 159:9	353:12,15
333:11 335:10	thoughtful 55:8	159:20 160:18	358:4 361:10
335:23 338:7	thoughts	161:5 162:9	times 86:13
341:4,21,23	167:20 172:5	167:20 169:18	98:18 137:18
343:11,14,23	thousand	173:8 174:8,10	137:24 143:14
348:9,14	127:12	175:20 178:20	144:12,15,21
349:15,20	three 19:1 21:5	180:3,21,22	215:14 238:5
350:20,23	45:21 46:3	182:16 189:14	266:21 293:12
351:1,2,13	50:14,21 58:9	198:16 199:9	315:3
353:8,17 354:7	58:15,16,22	199:12 202:20	timing 95:3
354:10,13,21	60:24 110:11	204:3,7,21	96:6
355:22 357:1	295:19 315:3	213:22 214:1,2	title 37:20
357:11	thrown 354:19	217:13 218:3	40:22 200:18
thinking	till 152:10	221:4 229:20	250:9
105:10,10	tim 4:20	241:19 256:24	titled 26:6 37:6
180:10	time 9:8 11:9	257:24 261:15	128:22
third 155:17,19	21:8 30:21	261:18 266:1	toc 23:7
164:8 172:6	37:24 38:1	267:24 268:9	today 11:2,12
173:21 303:2	42:20 44:11	274:8,12,21,22	11:22 12:23
thomas 101:23	45:6 53:14,17	276:19,24	13:7 17:3,5,19
102:1	55:1 66:6 68:8	279:12,22,22	18:7,22 23:13
thompson 4:20	69:6 70:10,24	280:1,17	23:18 24:20
thorough 54:14	71:16,17 72:22	282:24 283:8	28:2,5 29:7,11
thought 24:11	73:3,13 74:4	283:23 286:15	35:4 36:7
36:23 40:8	74:16 83:13,16	290:8 292:1,15	107:15 138:15
44:10 57:16	85:4 89:12	292:20 293:5	147:5 180:5
70:5,14 92:8	90:23 97:23	297:12,15	184:6 338:16
102:22,24	98:24 100:5	302:14 313:8	353:16 358:4

today's 9:7 13:19 25:7 358:12	toxic 47:20 toxicologist 62:16	transport 8:10 16:11 31:14,19 38:4,8,13	transportation 55:17
together 33:8 119:4,20 290:1 351:3,12,14	track 330:7	46:16,17 48:3	transported 55:14 181:15
told 75:8 139:1 202:15 234:18	trade 131:4 184:3	49:15,20 50:4 52:10 55:19	transuranic 49:11
tom 102:2,9,13 129:11	trained 344:5	62:3 70:8	travel 174:15 174:21 175:8
tonkin 82:23	training 71:6,9 71:9	71:13 74:2 91:20 92:10	189:2,6,13 303:8
took 88:12,18 93:20 163:7 167:17 218:4	trains 55:12	98:16 103:14	traveled 189:1
tool 81:4	trait 185:19 186:9	109:18 110:1 110:14 113:24	traveltime 153:20
tools 226:4 263:9,11	transcribed 167:11	116:9 117:12 117:16 119:3	treatment 87:23 122:4
top 45:7 95:17 223:4	transcript 5:7 6:23 166:14,18 172:18 175:13	119:18 120:2,6 120:7,23	230:24 272:10 272:12 275:21
topic 52:8 200:10,11 246:23	185:8 186:3,4 194:1,13,14	122:10 123:4 124:11,12	280:13 298:3 298:19 299:7
topics 55:3	216:17 265:3,5	150:2,4 151:8	299:10 300:18
total 31:16 66:12,19,20 67:3	268:22 282:2,3 282:4,13	157:11 158:4 173:12 177:6 177:10 181:7	300:23 301:6 332:21 339:4 339:14
totally 179:3 212:21	284:19 360:5 361:8	183:11 194:18 197:8 203:3	trend 251:19
touch 69:16	transcripts 28:8,13 167:14	207:11,19	trial 260:11
towards 52:4 87:3 176:2 181:22 194:12 194:13 198:11 246:7 271:11	217:3 278:3	208:9 217:23	tried 181:9 346:14
	transfer 306:14	221:17 236:22	true 22:2 35:24 66:4 198:3
	transient 118:14	240:16 241:9 266:2,11,19	228:14 281:19
	transmissivity 118:18	300:17 301:3 304:4,13 314:3 314:14 315:21	334:12,12 336:21 360:8
	transparent 248:3	316:2,18 325:8	truth 11:16 192:18 228:17

			u
245:22 248:7 249:18 251:11 251:12 truthfully 11:23 try 13:15 29:16 104:15,16 111:21 155:9 181:23 182:1 229:3 244:18 253:19	168:2 176:7 193:20,24 201:7 202:2 206:13 222:22 227:5 239:5 254:23 262:14 265:11 269:9 276:12 282:12 287:4 294:6 326:1 331:24 333:15 345:24	93:20 99:9 100:6 102:16 116:9,20 119:6 148:6,9,21 175:22 189:12 190:2 218:24 224:6 250:7 256:23 266:7 267:16 268:6 268:10 273:17 274:1 288:4	u.s. 4:4 7:10,23 8:7 37:24 38:16 60:11 63:15 68:9,16 69:3 71:5 89:10,13 100:7 100:11 102:3 104:5,10 132:20 140:10 200:23
trying 20:18 31:6 43:12 48:23 105:2 149:10 247:2 tt 138:19 179:11 267:8 270:11,16,19 270:23 271:14 271:15,24 272:7,7,17 273:1 274:2 275:2,9,13 280:11,21,24 281:12 288:13 319:6 tuesday 1:15 2:8 166:21 turn 105:23 109:16 132:9 134:22,24 135:5 140:2 142:10 152:13 152:14 155:4	turned 21:15 21:17 253:22 275:6 347:24 turning 214:6 282:1 turns 253:17 264:14,15 tvd 217:14,21 twice 29:20 30:13 76:23 244:20 two 14:3,10 15:6 16:7,20 17:4,18,23 24:8 30:7 32:21,23 36:14 42:7 45:21 46:8 47:3 65:16 68:4 70:3 72:16 74:4 76:2 78:10,10 86:10 88:12 90:8	297:8,23 305:10 306:13 312:11 315:2 321:12 325:9 344:19 type 55:20 102:8 177:1 179:5 183:22 190:24 types 16:15 typical 114:10 114:12,15 121:18 123:2 typically 40:9 47:16 113:24 114:7 122:9,10 122:13,13 123:5,17 274:5 313:8 typing 12:3 typographical 23:4	ultimate 142:5 147:10 210:9 213:16 238:9 248:9 346:10 ultimately 194:18 230:24 umbrella 58:10 unable 11:22 unacceptably 227:21,22 unbounded 259:16 260:18 uncertain 327:1 337:16 uncertainties 346:15 uncertainty 111:4,7 117:14 118:22 119:19 119:21 120:8 184:12,18 195:17 196:3,4

196:14,15	360:1,4,12	63:11,13 64:19	62:5 63:21
197:14,16,19	underground	77:7,10,14,19	70:12,16 73:7
197:21,22,23	111:19 112:5	78:1 79:15	78:17 81:6
205:16 207:7	277:11	80:23 82:20	85:7 90:3 99:1
207:10 214:17	underlying	84:17 87:19,20	103:3 105:7
215:8,12,19	43:20 214:17	90:20 107:3,24	112:10 125:8
216:7,20	215:8,12 351:7	117:1,4 120:13	129:24 199:2
224:15 225:11	351:8	120:16 141:18	214:5 233:23
229:2,8 231:16	underneath	145:17 149:11	276:8 329:4
231:19 232:22	26:9 133:22	159:6 167:1	344:21
234:7,9,12	295:10 326:13	172:23 173:8	undertaking
236:19 245:24	understand	174:20 186:16	54:5
248:3,18	11:5,19 25:4	190:22 191:8	undesirable
249:14,16	56:9 58:3 68:3	212:1 226:16	193:5,7,11,13
251:14 266:12	87:16 114:20	230:21 231:1,2	undue 63:17
266:20 277:23	114:22,22	235:2 244:2	64:16
323:23 327:1	115:6 123:6	249:20 255:12	unexpected
329:8 337:17	146:9 183:5,6	256:1 261:3	183:12 231:20
337:23 347:15	183:8 210:15	306:18 328:19	232:23 308:13
348:3 350:24	226:20 263:10	333:5 352:2	unfair 288:2
354:9,13,24	265:1 292:4	360:11	unique 245:10
355:1,1	293:9 303:14	understandings	unit 109:5
under 11:15	306:22 307:12	62:9	312:12
39:10 56:16	320:7 335:11	understood	united 1:1 4:3
58:5,10,17	338:13 348:2,8	13:3 15:18	9:13 10:2,5,7
59:3 60:14	understandab...	16:18 17:6,12	139:19
61:4 111:16	348:14	19:20 23:5	universe
116:5 128:4	understandable	27:18 29:18	260:18
132:10 157:24	20:14	30:11 31:21	university
173:1 184:10	understandably	34:1 37:3 39:3	44:19
257:16 295:11	294:21	41:12 42:11	unlimited
305:22 316:11	understanding	43:14 44:6	260:13
326:16 328:8	15:19,21 56:18	47:23 49:12	unrealistic
330:7 347:16	58:22 59:13,22	50:8 55:23	260:6

unreasonable	207:18 209:24	134:11 135:24	231:5,5,8
212:17	210:9 211:3	136:10 137:13	241:14 258:9
unsaturated	213:15 214:1,2	138:4,20 139:8	263:9 352:5
174:17 313:8	214:10 220:8	146:4,20	user 213:23
322:15	228:2 231:21	147:18 150:9	355:3,8,23
unwarranted	231:23 232:16	158:14 159:24	356:2
328:11	232:23 233:5	160:6 177:14	users 115:3
update 36:8	233:14 234:13	179:4 187:22	213:16
updated 23:17	234:17,18	197:5 203:6	uses 64:2 104:2
36:4	235:3 247:5	206:4 209:21	114:11 115:8
upper 248:16	248:12 255:21	209:21 210:14	120:3 153:8
334:15	263:16 264:1,7	210:19 211:6	usgs 44:24
upwards 48:13	264:13 276:19	212:18,23	53:13 69:5
usable 104:17	314:2 318:16	217:9,22	71:8 77:7,15
usage 187:17	320:9 321:20	226:12 230:7	79:7 102:4
usdoj.gov 4:12	323:7,10 330:2	236:18,20	using 49:13,16
4:13,14	334:2 353:11	237:10,17,21	117:8,12 134:2
use 64:24 70:7	355:3,8 356:7	237:23 238:7	140:14 181:8
82:22 88:5	356:11,11,14	238:22 240:12	181:12 188:7
104:9,13,22	357:16	241:16 244:19	214:21 229:18
105:5 107:14	used 44:23 47:3	247:18,24	244:3,7,18
111:20,24	50:24 71:5,11	251:4 261:4	245:13 246:12
114:19 115:11	79:6 82:4,16	262:5,24 263:9	247:15 252:23
115:12,13,13	103:22 113:24	275:17 277:22	255:7 262:18
115:14,16,18	114:7,13,14,18	279:10 297:24	262:18 274:11
115:20 119:17	115:22 119:1,2	298:11 306:14	305:13 315:3
119:20,20	119:3 120:18	307:17,18,23	315:17,23
121:17,19	120:20,21,24	315:5 317:11	316:20 317:23
123:2 125:12	121:4,20 122:9	320:13,24	318:5 319:16
131:6 138:9	122:10,13	321:15 327:19	320:18 322:17
142:7 153:10	123:5,10	334:16 339:5	323:19 324:12
180:24 181:16	125:21 126:2	352:16 357:9	326:18,21,24
182:13,15,24	126:10 127:10	useful 158:2,3	327:9 342:12
183:16 195:24	128:7 129:21	229:23 230:19	355:17 357:7

357:20	249:12 250:11	256:14 259:13	velocities 313:3
usually 37:18	250:17,22	259:13 280:2,3	velocity 302:7,8
44:4 182:11	254:1,13,22	290:10 292:22	302:10,24
utah 31:5,8,11	255:8 262:9,19	292:22 293:13	303:1,3
32:4	262:19 264:6	294:17 295:8	verbal 107:2,8
uterus 132:18	264:21 357:3	295:18 296:7	verbatim 361:8
utilizing 334:20	357:10	307:17,18,22	verification
v			
va 2:17	validating	307:23 309:12	244:4,8
valid 238:22,23	263:13	309:13 318:20	veritext 9:6
239:3,19,24	validation	320:13	version 120:20
240:4,11,21	243:12,13,16	variability	versions 87:14
241:13,22	244:8,17,19	110:13 171:13	versus 9:13
242:2 244:3,14	254:9 255:13	279:21 282:23	36:16 145:18
244:16,19	255:20 256:9	284:9 310:2	184:7 287:9
245:1,11,13,22	256:21 257:9	349:19	289:21 295:5
246:12,13,14	257:12,20	variable 303:13	296:3 317:16
247:15,18,19	258:4 357:3	303:19 335:7,7	355:5
251:3,5 253:15	validity 239:15	348:10,15	vertical 313:3
254:22 264:4	244:21 246:24	variables	vertically
264:21 357:3,7	valley 31:4,8	301:20 305:1	329:24
357:17	valuable 105:4	variance	vicinity 7:9,22
validate 7:14	value 92:6	292:21	8:6 200:23
242:14 248:24	135:18 228:14	variations	vickery 1:23
249:1,6,21	260:14 266:1	153:16	2:21 10:12
250:7 253:6	278:19 279:16	varied 141:21	361:3,21
254:5,17 255:9	288:7 293:2	varies 56:23,24	video 1:12 2:11
257:16 262:5	306:12 319:19	104:10 208:19	9:9
validated	319:20 336:4	various 263:4	videographer
243:22 244:16	values 34:24	vary 111:13	4:17 9:3,6 10:8
245:12,16	35:6,6 91:12	198:15,16,18	83:12,15 85:23
247:12,23	118:7 203:9	347:15	95:8,11 149:13
248:8,20	205:6 206:7	varying 293:12	155:8 162:8
	213:20 228:3	vegas 31:6,7	199:8,11
	255:18,21	32:1	261:14,17

297:11,14 330:13,16 358:9 view 98:1 323:15 vinyl 165:14,23 virginia 2:23 9:12 361:2,5 361:22 visited 82:19 100:1 vitae 5:18 35:22 36:1,8 36:16,21 voc 299:3,15,17 300:7 vocts 165:13,22 299:10 voicemails 19:5 volatile 132:19 140:8 147:12 volatilization 299:7,9 300:21 301:8 volume 7:16 108:24 166:13 194:2 320:19 320:22 volunteer 44:4 52:22	waddill's 240:9 wait 151:1 220:12 waived 358:15 want 13:18 57:2 104:8 116:16 150:21 150:23 160:20 163:22 164:4 170:2 172:8,12 183:1,6,16 192:15 193:20 197:15 209:13 210:23 211:6 212:20,21 213:15 221:16 222:22 245:5 255:2 278:24 279:11 280:2 284:7,22 303:24 305:6 312:22,22 330:12 335:15 337:10,24 338:1,3 356:11 wanted 11:11 18:24 31:9 37:13,15 39:10 61:6,21 69:23 75:8 84:8 103:7 109:21 163:3,20,24 168:2 202:2 227:5 231:6	262:4 278:18 280:17 284:10 287:4 297:22 301:10 330:24 332:15 333:20 343:9 345:19 355:8 356:14 wanting 172:1 wants 355:3,24 warnings 216:11 washington 2:15 4:10 9:10 waste 47:8,14 47:14,18,22 48:15,24 49:9 49:10 50:9 53:4 54:6,8,10 55:13 75:1 237:17 wastes 47:16 47:19 49:11 water 1:7 6:21 7:8,14,21 8:5 8:13,23 9:13 30:4 31:9 32:4 33:6 38:4,6 42:14,17,19 43:16 45:12 48:11 51:11 63:18,20 68:4 80:9 85:10 87:17,22 89:12 90:17,18 91:4	92:21 95:21 99:13 104:7 105:15 108:24 113:21 115:3,8 115:10,11,13 115:14,16,18 115:20 116:15 116:19,20,22 120:11 121:5 121:10,11 122:3 132:6,20 133:6 134:2,10 134:13,15 135:15 136:2 136:10 140:10 140:15,18,20 152:20,24 153:3,5,21 158:1 164:15 164:20 175:21 176:2 178:21 179:24 189:15 193:10 200:22 211:5 213:1,4 213:6 230:23 230:24 240:20 241:17,18 242:13 243:5 243:22 244:10 247:12 256:20 256:21 266:8 267:8,17,20,23 268:3 271:13 271:16,21
w			
waddill 239:20			

272:9,10,12	305:8 317:8	211:5,18,23	withdrawal
274:7 275:20	321:9 339:6	213:5,7,12	273:18
275:21 280:12	353:14 357:17	230:23 266:23	witness 9:21,24
280:13 290:17	ways 184:16	271:6 272:22	10:12 19:22
290:23 293:24	221:2	274:6,10,19	24:6 35:16
294:14 295:14	we've 17:18	275:23 276:4	54:16 57:11
296:20 298:3,6	19:18 50:15,22	290:17,23	59:19 69:10,19
299:3,7,10	53:5 72:13	291:5,17	73:9 75:12,16
300:7,18,19,22	83:10 137:9	295:19 298:6	78:24 79:19
301:6 302:10	145:4 160:17	315:2 319:24	80:19 95:15
303:1,3,8,9	187:20 193:4	320:4 324:24	97:13 99:6
320:16 325:15	215:13 216:16	332:23	107:7 112:22
332:20,23	255:3	went 18:1 72:2	112:24 114:3
334:2 339:4,14	weapons 47:15	77:11,16,19	114:10 117:22
340:6,15	week 13:24	88:23 147:9	123:14 125:16
341:15,20	14:9 15:6 16:7	245:17 271:16	126:7 133:15
345:10 346:12	17:23,23 67:10	272:3 277:20	137:5,19
350:6 357:4	72:16 90:8	319:19 323:3	138:13,24
watermodeling	171:11,12	wet 305:13	139:3,13 141:5
7:3,12 8:20	week's 16:19	whipple 53:21	141:17 142:3
332:5	weeks 13:21	widely 40:5	144:1 145:11
way 71:14	19:23 175:21	241:12,20	146:10,23
72:12 75:14	189:12 252:9	244:21 293:12	147:8,22,24
91:13 112:14	weight 288:7	widespread	160:5,13
113:15 114:22	291:2	42:22,23	165:18 166:3
115:5,14 120:9	weighted 298:1	williams 4:22	173:3,7 175:1
171:12 176:3	weitz 3:14	willingness	179:16 186:23
181:17 182:11	weitzlux.com	330:22	187:14 188:2
182:22 185:10	3:19	wipp 49:6 51:4	190:7 191:21
195:24 197:9	wells 31:10,24	51:4 52:1,13	192:14 219:7
197:11 208:12	111:24 113:4,5	52:19,19 53:6	220:14,17
241:19 258:13	113:12 122:3	127:9,20	222:1 223:13
260:3 267:10	168:9 178:22	wish 244:1	224:10 225:23
274:14 288:6	179:24 180:23		228:21 230:12

234:23 246:18	217:3 226:18	world 46:1 104:5 106:20 123:11 138:21 146:21 165:16 240:1,3 331:4	yeah 14:8 18:21 19:12 20:16,19 27:11 27:14 37:19 38:22,24 41:4
246:22 249:8	246:15 274:23		41:19 42:16 43:22 47:24
249:24 251:9	283:9 285:3	worlds 241:5	53:2,7 60:13
253:2 258:19	343:8 355:17	worry 213:10	60:13 61:15
263:21 270:8	356:7 357:3,23	worth 24:11 worthwhile 40:9 44:10	62:8 68:13 69:2 72:13 73:14 78:20 80:7 85:8
273:3 286:8,23	work 44:24	wrapped 84:4	95:13,22
287:17 288:17	45:11,15 50:11	330:11	101:15 103:18
292:3 295:2	50:16,17,23	write 222:6	103:18 105:10
299:21 303:22	65:8 66:23	232:5,13,13	109:15 110:18
309:6 318:8	67:23 71:5	writing 40:17	110:20 112:24
323:18 329:1	72:2 73:19	41:2 99:19	118:2 119:5
333:9 335:23	74:10,12,23	written 148:24	122:16 126:7
337:8 346:24	75:3 77:16,19	wrong 20:17	128:17 131:1
348:7 349:14	78:11 79:5,6	142:16 170:3	134:8,19
350:11 351:19	91:19,21,21	183:24 225:19	141:11 149:19
352:15 353:17	99:13 163:5	239:9 253:17	151:20 155:2
358:7 361:6	207:11 214:20	254:24 255:14	156:5,5,5,7
women 132:24	226:13 299:12	264:9,10	157:19 158:7,7
wondering	344:2	292:12 308:9	163:18 168:16
118:23 226:11	worked 32:6,22	wrote 41:10	169:10,14,17
word 23:3	33:16 53:13	150:17 156:4,7	174:5 178:10
58:13 106:5	66:6,11 72:4	156:21	178:11 182:4
110:18 243:13	74:1,3 77:1,7	y	182:22 186:1,5
244:2,3 247:15	77:20 78:16	y 46:5	187:14 188:2
357:7,10	81:24 89:10		188:13,16,21
words 40:24	102:3,9 162:24		201:13 207:1
52:21 103:4	312:3 321:11		
110:22 112:4	workers 347:7		
118:7 129:9,13	working 40:16		
130:11,14,15	74:17 79:3		
168:19,23	349:9		
170:14 177:23	works 76:13		
180:6 195:2	81:13 145:16		
203:12 211:2	145:16		

219:24 223:7 224:2 230:9 232:11 234:14 239:7,11 246:9 252:10 265:8 267:6,7 268:7 268:11,11 269:6 272:22 278:9 289:9 290:9,9 291:21 295:3,7,9 301:12,16 307:15 308:3,5 308:18 309:1 310:15,20 311:20 312:8 319:17,17 325:3,7,23 327:6 328:5 329:19 332:14 335:10 340:14 353:3,23 354:14 357:20 357:23 year 42:7 77:18 77:18 102:16 132:18 151:18 152:7 159:11 163:6,13 205:6 256:23 257:5,6 264:8 266:6,7 266:23 267:15 267:16 268:5 268:10 347:9	yearly 213:24 years 5:21 30:2 30:19,20 37:7 37:11 38:22,23 38:24 40:2 42:7,7 44:20 45:6 50:6 71:4 71:12 72:24 74:4,11,14,22 77:7,21 85:5,6 96:20 101:10 102:11,13 124:24 127:12 152:1 156:7 159:16 172:4 172:10 173:24 175:14 184:4 189:1 205:4 211:22 215:16 223:24 237:18 265:24 266:7,8 267:16,17,20 267:23 268:6 268:10 269:21 269:22 312:3 317:4 321:11 353:14 yep 161:1 yesterday 14:4 17:1,11,14 19:24 yesterday's 16:22 17:8	yield 176:20 177:22,22 178:6,17,20 179:21 210:24 318:22 yields 118:14 245:19 259:22 281:14 324:2 york 3:17 102:10 z zero 65:3 98:5 98:18,20,24 125:3 168:12 197:3 272:4 296:21 326:19 327:10,19 zone 174:17 zones 322:15 zoom 4:18
--	---	---